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A Model for Teaching Green Information Systems
in Higher Education

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By
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Abstract

The purpose of this study was to respond to a call to the Information Systems (IS) discipline to provide solutions to address global challenges such as the seventh Millennium Development Goal of ensuring an interconnectedness of society and the environment. Many academic disciplines have recognised that sustainability is one of the most significant challenges of our time and thus needs to be included in curricula; IS, as a discipline, needed to fill this gap. A longitudinal six-year study was undertaken at the University of Cape Town (UCT) Department of IS to introduce the concept of “Green” IS into a project management course with students required to measure an aspect of the campus carbon footprint. Drawing on Design Science Research, the author used kernel theories of Butler’s Model of Green IS and the Scharmer’s Theory U to inform the design. The goal of the curriculum intervention was to design a model with outputs of key Green IS technical and social competences. The intention was also to create an impact with a reduced Carbon Footprint at UCT, despite the current absence of regulatory pressure. A total of 183 students were involved in the study over a period of six semesters where the theories of Green IS were presented as the underlying frameworks for their course. Key principles were drawn from international best practice, including how to address “wicked” sustainability problems and adopting a focus on developing sustainability solutions. Formative evaluations were conducted at the end of each cycle of the design development. Archival evidence, as well as student reflective essays, was employed, and content analysis and coding of the empirical data were conducted using a data analysis software tool. Experts were invited to summatively evaluate the model in practice, and their questionnaires were also coded in Atlas-ti and tested for co-occurrences. The contributions are provided on two levels. A contribution is made on a theoretical platform by the design of “The Green U”, a model that evolved iteratively and has its roots in the kernel theories of both Green IS and change management. On a practical level, the research offers guidance to IS educators on how to integrate sustainability into their courses. Via enabling The Green U to be exapted into other emerging IS themes, this research project thus provides the opportunity for a seam of rich possibilities for further quantitative and qualitative research.

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Chapter One – Introduction

During the Arctic autumn of 2015, the author travelled close to the North Pole (81,3 °N) to develop an understanding of climate change. First-hand experience was gleaned and visual data collected as part of exploring how to incorporate sustainability into the Information Systems (IS) curriculum. The author boarded an ice-strengthened boat in Svalbard, north of Norway, to assess the impact of climate change on a range of phenomena from polar bears to glaciers and a detailed visual diary was kept to create a bank of images for presentations to students.

The phenomenon of interest was that, although most academic disciplines had rallied to the call to incorporate sustainability issues into their curriculum, sustainability remained a strategic opportunity for IS departments (Dwyer & Gomez, 2009; Hasan, Molla, & Cooper, 2014). This was a problem with no easy solution, which led the author to explore a nascent stream of research, called Green IS, a research area which involves the collaboration of people, technology and systems thinking to achieve sustainability outcomes, as well as an ability to anticipate the future. This resulted in the awareness that research was needed about how to integrate Green IS into the undergraduate curriculum.

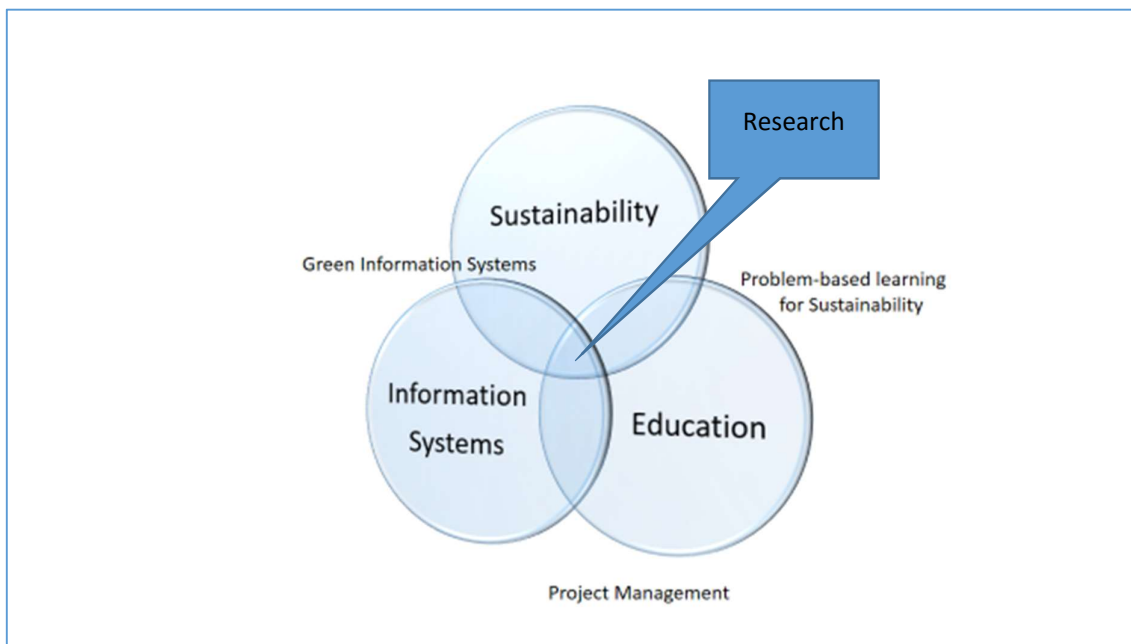


Figure 1: Domain of research at the intersection of IS, sustainability and education.

1.1 Context

Before introducing the topic, it is important to situate the context of this research, which is in the confluence of sustainability, education and IS as shown in Figure 1. In the diagram there are intersections between three elements – the discipline of IS, the issue of sustainability, and the domain of education.

Information Systems is the study of computer-based information processing systems, which support the decision-making and management of organisations (Walsham, 2012). This definition is, perhaps, too narrowly focused on the organisational context. The depth of IS research may be better expressed by Lee (2000) who argues that the discipline is interested not only with technical and social systems, but the phenomena that emerge when the parts of the system interact.

Sustainability is an issue with many definitions. Although it has its roots in the concept of “Sustainable Development”, a term which was coined at the United Nations 40 years ago, its meaning has evolved since then. Originally, Sustainable Development envisaged enabling current generations to meet their needs without compromising the ability of future generations to meet their needs (WCED, 1987). Environmental Sustainability takes many forms, and can be related to climate change, Greenhouse Gas (GHG) emissions, burning of fossil fuels, droughts, fires, extreme storms, biodiversity losses and other phenomena. Actively-publishing climate change scientists have reached an overwhelming consensus that man-made activities are responsible for releasing unsustainably high levels of carbon dioxide and other gases into the atmosphere resulting in climate change (Hansen, 2005; Kokic, Crimp, & Howden, 2014; Kokic, Howden, & Crimp, 2014; Oreskes, 2004). Burning of fossil fuels and deforestation released about 40 gigatonnes of carbon dioxide in 2016 (Harvey, 2016). In addition, a recent Arctic winter registered 20°C above its normal range (Harvey, 2016). Closer to home, Cape Town has experienced its worst drought in 311 years (Wolski, 2018). This has led to the perception by the premier of the Western Cape that Cape Town is “*a rapidly-growing city caught in the claws of climate change,*” (Zille, 2018, p.1). The research study is also a response to global challenges, such as the seventh Millennium Development Goal, of ensuring an interconnectedness of social and environmental concerns (Hajer et al., 2015; Waage & Yap, 2015).

Education is also a construct which requires definition. It derives from the word “educate”, which aims “*to give intellectual, moral, and social instruction ... esp. as a formal and prolonged process*” (Allen, 1990, p.373). Two aspects of this definition are worthy of note. The first is that the process of

education is seen to go beyond mere intellectual instruction, but also concerns the moral and social development of the learner. This involves the growth of personal assets such as values, beliefs, attitudes and behaviours. The second is that the process is seen as formal and prolonged. Of course, with the advent of social media and other technologies, education can be informal and of short duration. However, for the purposes of this study, education is focused on the formal, face-to-face mode. In addition, it is restricted to university education, and in particular the engagement of undergraduate IS students.

Returning to the positioning of this research, on the left hand side of Figure 1 it can be seen that sustainability and IS overlap; it is this intersection between sustainability and IS that the positioning of “Green” IS occurs (Seidel, Székely, & vom Brocke, 2015). The construct of Green IS was coined in 2011 when the enabling and transformative power of IS was identified as a potential solution to environmental problems, for example via environmental management systems, telecommuting, and other interventions (Chen, Watson, Boudreau, & Karahanna, 2011). Green IS has more recently been defined as *“the application of IS solutions for the challenges of environmental sustainability”* (Elliot & Webster, 2017, p. 367).

A further observation of the diagram will disclose there is a common area between sustainability and education and this has led to the emergence of a great deal of literature. One of these is problem-based learning for sustainability (Brundiars & Wiek, 2013), which forms the basis of Chapter Three.

Another overlap occurs between IS and education, and it is this nexus where academics are challenged to provide relevant programmes, such as project management, as shown in Figure 1 (Topi, Valacich, Wright, Kaiser, Nunamaker, Sipior, & de Vreede, 2010). The problems are manifold. For example, in IS, there is an ongoing need to update curricula to keep abreast of technological changes and ensure that graduates are equipped for industry, which has a growing appetite for IS graduates. This technological driver is paramount, meaning that finding space for other important issues in the curriculum leads to a reticence by academics to change (Wayman & Kyobe, 2012). South African universities, in particular, are often trapped in historical legacies where departments were based on North American models with little local relevance and this need to transform to reflect a local African relevance also compounds the challenge for curriculum change (Wayman & Kyobe, 2012).

In addition, the literature on sustainability in higher education has proposed a combination of project- and problem-based learning to foster deep learning (Brundiars & Wiek, 2013). However, the conundrum posed here was how to involve students in project- and problem-based learning of Green IS. In addition, there is the challenge of student engagement – how best to engage students in Green IS to ensure deep learning? It became clear that there was a lack of prescriptive theory in this regard.

A specific need to change the curriculum to create graduates who would have the ability to lead sustainability interventions had been identified in the literature (Sterling & Huckle, 2014). However, there has been an absence of clear guidelines on how to incorporate sustainability into the IS undergraduate curriculum (Lavarack & Elliot, 2012) and the teaching of Green IS is critical for the future of the discipline, as it would enable scholars to make a global impact (Hasan, Molla, & Cooper, 2014).

At the center of the diagram, the intersection of the three segments forms the context for this research, namely the integration of Green IS into the Project Management Curriculum where project- and problem-based learning for sustainability is the phenomenon of interest.

1.2 Problem Statement

The central problem that this thesis addresses is how to create a Green IS curriculum that is relevant and effective. This is placed within the context of student engagement in Higher Education with the vision to create students who will experience deep learning of sustainability and simultaneously develop a range of graduate attributes including systems thinking and interpersonal competences. This will equip them not only with technical skills, but competences to lead and manage sustainability initiatives when they leave university and go into the world where they will encounter the ubiquitous problem of resistance to change. Finally the lack of Green IS in Africa is also at play. This issue is clearly a complex one, with many dimensions, which will now be discussed.

Firstly, there is the problem of updating the body of knowledge in the curriculum of the IS discipline itself, which is dualistic, meaning that its roots are in both the technological and social sphere. As Lee expresses it, the discipline is concerned not only with technical and organisational systems, but is also interested in the phenomena which emerge when the two interact (Lee, 2000). This adds a layer of complexity, as students need to engage with both the technical aspects of sustainability, such as measuring carbon footprints, as well as developing interpersonal competences to work

collaboratively. Although IS has been at the forefront of creating solutions in a broad range of areas, there has been a tardiness in developing impactful research in Green IS (Seidel, Bharati, Fridgen, Watson, Albizri, Boudreau, Butler, Kruse, Guzman, & Karsten, 2017). Part of the rationale for this observation comes from recent literature on the response from a range of disciplines to the issue of climate change. Science, engineering, the arts, law, education and other fields are well represented (Jones, Selby, & Sterling, 2010; Lozano, 2010). This study is located in academia, specifically within the Higher Education sector, and focuses on the learning and teaching of sustainability in IS, as this has been identified as a gap in the academic literature (Laverack & Elliot, 2012).

A second dimension lies within the multi-faceted challenge of how to empower IS students for the working world. One needs to bear in mind the dynamic world of the IS professional, since technology is changing (Janicki, Cummings, & Kline, 2014). In addition there is a skills gap between the university and the workplace and better alignment between graduate education and industry expectations is needed (Scott, 2012). Graduates must not only have an understanding that systems include people, hardware, software, and data in a competitive global environment, but they must also possess strong thinking skills and the ability to use system concepts for understanding problems (Topi, 2012).

A third problem concerns a reluctance by Higher Education Institutions to holistically address issues like sustainability. In spite of 390 universities signing the 1994 Talloires Declaration, which commits them to teaching environmental literacy to all undergraduates, this goal remains elusive, particularly in Africa (Murphy & Ali, 2016). Many academics do not take sustainability seriously and there is a resistance to change. What has been described as a “collective blindness” to the systemic issues shaping the future is present in education systems and deep learning within educational policy and practice is needed (Jones, Selby, & Sterling, 2010 p.5).

A fourth, and perhaps the most important aspect of the problem, is that of sustainability education. Assessment of sustainability in Higher Education remains fraught with difficulties, not least of which is the acknowledgement that sustainability is a contested concept, and one which may require conceptualisation at faculty level (Stough, Ceulemans, Lambrechts, & Cappuyns, 2018). Although much research has been done about how best to educate students about sustainability (e.g. Lozano, 2010; Lozano, Ceulemans, & Seatter, 2014), it remains unclear how Green IS can be incorporated into the curriculum. How to engage students in a way that promotes deep learning will need to be

addressed possibly via problem- or project-based learning or a combination of the two (Brundiers & Wiek, 2013). A range of sustainability competences will also need to be developed during the course of the intervention (Luederitz et al., 2016). These will include systems thinking and other competences (Wiek et al, 2015).

Finally, a fifth dimension to the problem concerns the shortage of Green IS research in Africa. This was confirmed by means of a literature review. It is surprising that sustainability issues in Africa have not received sufficient academic attention as the following comment attests to the exceptional vulnerability of the continent “... *based on the scientific evidence, human-induced climate change is no longer disputable and ... its impacts on food production, human migration and available water and other resources will make Africa, with its multiple stresses and low adaptive capacity, even more vulnerable and insecure*” (Strydom & King, 2000, p. liv).

To sum up, the issue of integrating sustainability into university systems may be termed a “wicked” problem, as it is not easily solved, given its many dimensions and its complex network of internal and external stakeholders (Adams, Martin, & Boom, 2018, p. 435). A study which prescribes how to integrate this will therefore be a useful contribution to the IS body of knowledge. The challenges raised here created the opportunity to propose an approach to integrating Green IS into the curriculum to enable students to engage deeply with the issue of sustainability.

In essence, the problem is as follows: The field of Green IS (the collaboration of people, technology, data, processes, and systems thinking to achieve environmental sustainability objectives) has not yet been integrated into the undergraduate IS curriculum, despite the global and local need to raise environmental sustainability awareness in students.

1.3 Objectives

The primary objective of this study is the development of a prescriptive model for integrating Green IS into the undergraduate IS curriculum. Secondary objectives will need to be met to support the development of this artefact. These include:

- Investigating extant theories about the nascent phenomenon of Green IS, a research domain which seeks to use the enabling and transformative power of IS to achieve sustainability objectives;

- Examining the literature regarding sustainability in Higher Education for the purpose of identifying potential theories to undergird the development of the model; and
- Evaluating key constructs, including key sustainability competences via formative and summative evaluations by students, sustainability experts and education experts. The formative evaluations will help to guide the next iterations of the model as it develops in the classroom. The final summative evaluation will help clarify which constructs are most useful in the final model.

1.4 Scope

In addressing this problem, certain boundaries for the research were set. First, the research project fell within the ambit of Design Science Research (DSR), which has been accepted as a legitimate paradigm within IS (Gregor & Hevner, 2013). This philosophical stance has its roots in Simon's description of design as a focus on "*how things ought to be, with devising artefacts to attain goals*" (Simon, 1996, p. 114). This goal orientation and the importance of starting the research process with a problem, rather than a research question, is central to DSR. However, there are potential restrictions on generalisability that may apply with this methodology. In addition, the value of working in other paradigms, for example the richness of interpretivism or the validity of positivism were deliberately excluded from this study. This selection of a single paradigm, DSR, thus limits the depth of understanding uncovered in this study as the creation of descriptive theory was not the goal.

Second, the scope of the project was restricted to a single course in the IS department. A total of 183 computer science students who enrolled for project management courses, over a period of six years, were the subjects on whom the intervention was tested. This scope was chosen for practical reasons to enable the doctoral project to stay within a feasible frame. The implication of this is that there were a limited number of student evaluators for the formative evaluation. In addition, the fact that a single semester course was the site of the study indicates limits to its generalisability. However, there are possible ways to minimise this limitation, for example via exaptation, a concept that will be discussed later.

Third, the scope was limited to face-to-face interactions on a single campus, the University of Cape Town. This means that online or blended learning with a global classroom was not envisaged as part of this intervention at this stage, although it could have enhanced campus sustainability objectives by reducing the commuting impact on the environment.

Fourth, a limitation relates to the issue of time. The intervention was conducted over a semester-long course from February to May each year. The investigation encompassed six years in total, starting in 2011 and ending in 2016. The implication of this is that the incorporation of sustainability into the curriculum was, in effect, not sustained, as the process was halted in 2016 due to competing demands for project management undergraduate research in the IS department.

Fifth, although the students were asked to make recommendations, they were not asked to innovate and implement their recommendations for a more sustainable campus, as this would go beyond campus policies. The implication is that the impact of the intervention was limited. It would have been desirable to not only integrate sustainability into the curriculum, but also to achieve sustainability outputs, for example a reduction in the campus carbon footprint.

Sixth, there were learning-specific elements, which were scoped down. Although the students experienced such constructs as reflection and presencing, these elements were not highly developed during the intervention, due to time constraints. Other learning strategies such as coaching circles and the potential for life-long learning were not directly addressed. The implication of this is that the programme was not exploited to its full potential as envisaged by other authors such as Scharmer (2007) who made recommendations in this respect.

Seventh, the research was focused solely on the incorporation of Green IS into the IS curriculum. The topic of Green IT Research Design, implementation of recommendations, cross-curricular activities and other sustainability topics were excluded from the scope of the enquiry for reasons of infeasibility.

1.5 Research Methodology and Thesis Structure

The thesis has been designed as shown in Figure 2, which illustrates the cyclical nature of DSR research with iterative cycles of relevance, design and rigour. The thesis consists of eight chapters, each one of which fulfils a specific objective.

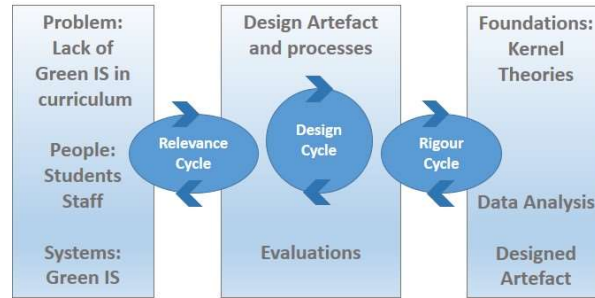


Figure 2: Iterative cycles of relevance, design and rigour, based on Hevner (2007).

In support of the research aim, the first two chapters explore the literature that gives the contextual background to the study with an analysis of what previous authors have found. Chapter two examines the growth of Green IS as a research stream, distinct from its predecessor, Green Information Technology (IT). A contribution that this literature review makes is that it is one of the first 10-year analyses of Green IS as a stand-alone research item. It is important to make the distinction between Green IS and the previous studies of Green IT where the focus was on technology. Green IS presents a nuanced difference. Although it includes IT artefacts as an essential component, Green IS is broader in scope than Green IT. Whereas Green IT encompasses the direct impact of energy consumption and waste associated with hardware and software, Green IS involves the enabling power of the human element in IS to support environmental sustainability objectives. After looking critically at the literature, the theoretical framework for Green IS will be selected as one of the foundations for the model design.

As indicated earlier, this study is situated at the nexus between Technology, Sustainability and Education and leads to the second literature review: Problem- and Project-Based Education for Sustainability. This forms the basis of Chapter Three, which will examine extant literature in the domain of Education for Sustainability as well as the change management literature with a view to finding a further theory on which to base the model development.

Building on the gaps identified in the previous chapters, the author set out in Chapter Four to find the most appropriate methodology and investigated candidate paradigms, including positivism, critical, interpretivist, and design science. The author makes an argument for design science as the most appropriate paradigm to help solve the research problem. The gist of this argument is as follows. “What” questions are best answered with a positivist approach and “Why” questions via critical or interpretivist paradigms. In contrast, “How” questions are best explored through Design

Science Research as this paradigm enables the development of prescriptive theory as well as making a practical contribution by helping to solve persistent problems.

A logical extension of this is Chapter Five, which illustrates the search for the artefact via a longitudinal study over a six-year period with each iteration including formative evaluations of the student experience leading to continuous refinement of the model.

As proposed by Gregor and Hevner (2013), the final step is to evaluate the artefact summatively, which is done in Chapter Six. Ethics approval was obtained before obtaining these evaluations. The artefact was evaluated for inputs, processes, outputs and outcomes and analysis was conducted via Atlas-ti.

Chapter Seven is a discussion of theoretical elaboration arising out of the empirical analysis. Finally, in Chapter Eight, the author lays claim to several contributions to theory and practice. Claims for relevance and rigour are argued, as well as directions for future research.

To sum up, then, the first chapter of this thesis explored the motivation for integrating Green IS into the IS curriculum. This was done via introducing the topic, outlining the research problem and objectives, clarifying the scope of the study and outlining the overview of the thesis. The following chapter will systematically examine the first decade of scholarly research in the field of Green IS.

Chapter Two – Systematic Literature Review of Green IS

2.1 Introduction

An important point raised in Chapter One was that a research problem had been identified in that there was a failure to integrate Green IS into the undergraduate curriculum. A logical starting point for to explore this topic and to fulfil the research sub-question which investigates the extant literature of Green IS, via examining what has been done by previous scholars. This chapter, then, represents an attempt to catalogue the response by IS researchers to the global challenge of sustainability, which they have described as Green IS.

This chapter begins by examining the shortcomings of previous literature reviews, especially the shortage of Systematic Literature Reviews (SLRs) in Green IS, and the need to clarify the differences between Green IS and Green IT. The limited timespan of previous Green IS literature reviews will also be addressed, and a critical approach will be taken to the predominance of conceptual papers in this body of work. The goal is to fulfil the mandate of unearthing previous descriptive knowledge created by theorists as well as “prescriptive knowledge” of human-built artefacts (Gregor & Hevner, 2013, p. 343).

2.2 Shortcomings of Previous Literature Reviews

There are three shortcomings of literature reviews of Green IS, which will now be discussed. They include (1) the shortage of SLRs within the Green IS existing literature, (2) the lack of clarity between Green IS and Green IT, and (3) the limited timespan of previous literature reviews.

2.2.1 Shortage of Systematic Literature Reviews in Green IS Body of Knowledge

SLRs offer the scholar a tool for conducting a rigorous literature review which is systematically carried out and comprehensively conducted, with the goal of identifying, synthesising and analysing the existing body of knowledge in a particular area (Okoli & Schabram, 2010). Until relatively recently, however, the practice of such a rigorous methodology for reviewing the IS literature was a neglected area, despite a long history of SLRs in other fields such as the health sciences (Okoli & Schabram, 2010). This gap has increasingly been filled with systematic literature reviews conducted over a range of relevant topics including the confluence between IS and culture (Geeling, Brown, & Weimann, 2016) as well as sustainability (Chasin, 2014). Indeed, the theme of Green IS has yielded a number of literature reviews, yet it appears that there are few exemplars of systematic treatment of the literature (Esfahani, Rahman, & Zakaria, 2015b). In addition, some authors have cautioned that

the scope, time and finances required for a comprehensive SLR may well be out of the realm of possibility for doctoral students (Okoli & Schabram, 2010). However, clear explication of choices during the review is not only useful to the field (Wolfswinkel, Furtmueller, & Wilderom, 2013) but also replicable, enhancing the rigorous approach of this study.

2.2.2 Clarification of Green IT and Green IS

Although the discipline of IS was relatively slow to respond to sustainability challenges, research has now coalesced into two streams: Green IT and Green IS (Malhotra, Melville, & Watson, 2013). Green IT may be described as minimising the harmful effects of technology (Murugesan, 2008; Murugesan & Gangadharan, 2012) whereas Green IS can be seen as maximising the impact of IS to enable sustainable processes and products, and is broader in scope than Green IT (Watson & Boudreau, 2012). The following definitions are helpful in clarifying the differences: *“Although IS and IT are often used interchangeably, we clearly distinguish between them in our research. Whereas IT specifically focuses on devices that store, transmit, or process information, IS is more encompassing, as it includes the integrated and co-operating set of people, processes, software, and information technologies to support individual, organizational, or societal goals. As IS and IT are distinct with IS being more encompassing (Watson et al. 2010), we posit that IT and IS contribute to the environmental issues differently. For the most part, it appears that IT is part of the problem (e.g., data centre’s energy consumption, electronic waste, etc.) while IS can be part of the solution (e.g., environmental management systems, telecommuting programs, etc.)”* (Chen et al., 2011, p. 6). This resonates with other scholars, who elucidate the interaction between technology and social structures, as shown by this definition: IS *“refers to technological as well as organizational subsystems, and where there is interest in the problems and solutions that emerge in the interactions between the technological and the organizational”* (Lee, 2000).

Few researchers distinguish between the Green IT and Green IS components (Dalvi-Esfahani, Ramayah, & Nilashi, 2017), while many consider Green IT and Green IS synonymous. This conflation of the two research streams is evident in a number of literature reviews (Esfahani et al., 2015b; Jenkin, McShane, & Webster, 2011; Wang, Brooks, & Sarker, 2015). Some even refer to the concepts simultaneously as Green Information Technology Systems (Bokolo, Mazlina, & Romli, 2017). This chapter is thus intended to impart clarity and focus solely on Green IS.

2.2.3 Limited Timespan

Some researchers acknowledge a limitation of their work regarding time span, such as Vazquez, Rocha, Dominguez, Morales, and Ahluwalia (2011) who compiled their studies when the research stream of Green IS was still nascent. Green IS has only recently started to mature as a separate field within the IS community, and this chapter is one of the first attempts at a full decade under review. Rigour is demonstrated by systematising the screening and search steps of the literature review, which typically covers a decade (Rowe, 2014) unless the phenomenon of interest covers several decades. As Green IS does not appear in the literature beyond the last 10 years, with no scholarly articles in 2007, this is a logical starting point. A similar argument was made for a 10-year literature review of Green IT (Asadi & Dahlan, 2017). The desirability of a decade-long scope has been proposed by a senior IS scholar (Rowe, 2014), hence this study provides a first 10-year analysis of the field of Green IS from 2007 (zero-based) until the end of 2016.

2.3 SLR Method

In order to demonstrate academic rigour, this chapter seeks to emulate guidelines enumerated for IS researchers (Okoli & Schabram, 2010) using an eight-step process which includes the purpose, protocol, search, screening, quality appraisal, data extraction, synthesis, and writing. Each of these will be addressed in this chapter, including reflections on the findings.

2.3.1 Purpose

In essence, the purpose of this review was to examine the body of Green IS research that had been published with a goal to find an appropriate model to inform the development of the artefact in this study. This was done by examining the spectrum of its evolution through four typologies established via a systematic evaluation of the literature on Green IS (and Green IT), which had appeared in top journals (Malhotra et al., 2013). This spectrum, which is described as the “value space” of Green IS and Green IT research includes four elements: *Conceptualise* (conceptual frameworks and literature reviews); *Analyse* (including case studies, ethnographies, empirical analysis); *Design-oriented* (Design Science); and *Impact*, which is described as implementation and demonstrating impacts with action research (Malhotra et al., 2013).

Malhotra et al. (2013) examined a six-year span from 2008 to 2013 and searched in the so-called “Basket of Eight” leading IS journals. This so-called basket of the top eight journals in the discipline had been identified by a group of senior scholars who ranked IS journals according to rigour of reviews, recognition of editors and international contributions (Hirschheim & Klein, 2012). During

the search by Malhotra et al (2013), they scoured the Web of Science using keywords “green” or “environmental sustainability” in these top eight IS journals. In addition, they searched using the words “ICT”, “IS”, “information technology”, and “Internet” in the eight top environmental management journals. They found 30 papers and categorised them according to the degree of impact of the research, illustrating Green IT and Green IS as separate concepts.

2.3.2 Protocol, Search and Screening

A protocol was established detailing the steps taken for this study, to enable replicability by other researchers. These included the secondary research objective to determine what Green IS studies had been published. In addition, there was a manual search through leading MIS journals; an automated search through Google Scholar; Inclusion and Exclusion criteria; and Quality Assessment, Data Extraction, Synthesis and Results. The author decided that as the field was in its formative stages, it would be appropriate, initially, to extend the scope beyond high-quality journal articles to include IS conference papers and books. A proxy for these scholarly articles was the use of Google Scholar with the Keywords “Green + Information + Systems”, rendering a total of 546 articles from 2007 until the end of 2016. Figure 3 shows the growth over the decade.

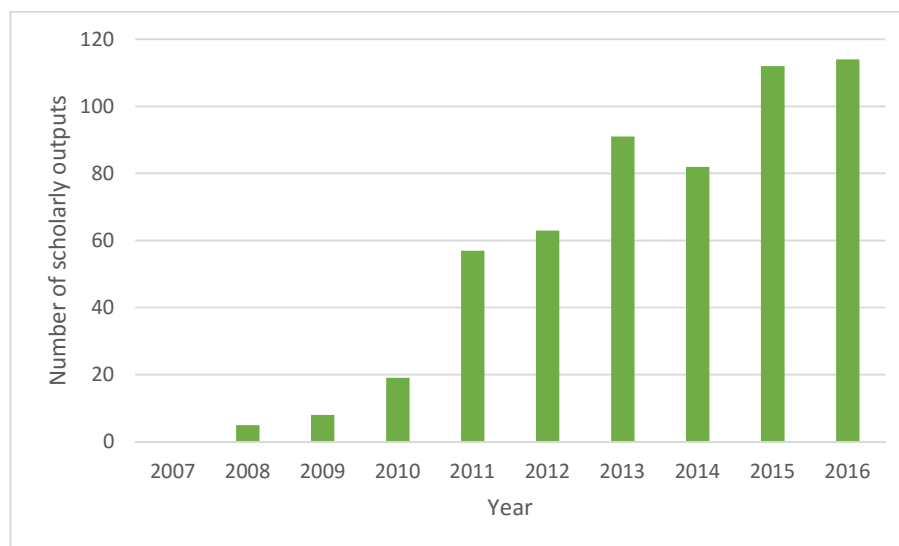


Figure 3: Growth of Green IS scholarly articles over the decade.

The field of Green IS has gained traction, thanks to a range of Green IS research agendas since Melville (2010). Although there were numerous conceptual and analytical papers, more impactful research has been published since 2013. The conceptual papers include literature reviews (Esfahani, Rahman, & Zakaria, 2015a; Esfahani et al., 2015b; Hasan, Molla, & Cooper, 2014; Kranz, Kolbe, Koo,

& Boudreau, 2015) as well as content analysis of sustainability reports and theory development (Reuter, Vakulenko, vom Brocke, Debortoli, & Müller, 2014; Seidel, Chandra, Reuter, Stieger, & Gau, 2014).

There has been much innovative work. For example, from Australia came a framework on how Small and Medium Enterprises (SMEs) market ecological responsibility on their websites (Parker, Bellucci, Torlina, Zutshi, & Fraunholz, 2014). Researchers in Africa explored local topics - sustainable supply chain management in Ghana (Kusi-Sarpong, Sarkis, Wang, & Leal Filho, 2014), Green IS on the Johannesburg Stock Exchange (Kotze, Van Belle, & McGibbon, 2014) and a Green IS framework based on the South African banking sector (Howard, Lubbe, Huisman, & Kloppe, 2014). The concept of the Smart city also attracted attention, in particular about educating students in a technology-driven world (Klett & Wang, 2015; McGibbon, Ophoff, & Van Belle, 2015) as well as Green IS within the education domain (McGibbon & Van Belle, 2015). Research on municipalities in the United Kingdom also yielded insights on the mechanisms required to achieve Green IS objectives (Butler & Hackney, 2015).

A trend was observed progressing from purely conceptual papers to research with greater applicability to design and implementation. This was in line with the call for IS researchers to do more impactful research (Malhotra et al., 2013). Germany appeared dominant in this space. From the University of Oldenburg came solutions on how to upgrade reporting, communication and benchmarking tools to enable product life cycle to be assessed as well as track sustainability indicators (Medel-González, van Vliet, Roeder, & Marx-Gómez, 2014). A decision support system for offshore wind energy in emerging countries was proposed by the University of Hannover (Koukal & Breitner, 2014), while the use of discrete event simulation in Green IS was mooted (Stiel, 2014). Researchers in Berlin developed a multiple-user tool for simultaneous processing of environmental data (Freiheit, Görner, Becker, & Fuchs-Kittowski, 2014) while the University of Goettingen created a solution for mobile devices to track carbon footprints during the process of meat production (Hilpert, Kranz, & Schumann, 2014).

2.3.3 Quality Appraisal

During this stage, a decision was taken to make a strategic choice on which papers to include in the SLR. At first, a summary of articles from two previous Green IS literature reviews was considered (Gholami, Watson, Molla, Hasan, & Bjørn-Andersen, 2016; Malhotra et al., 2013). However, this included journals which were not within the IS discipline. Papers in *Energy Policy*, as well as papers

in the Journal of Industrial Ecology, were not peer-reviewed by IS scholars, so were candidates for exclusion. The same argument applied to a paper in *Business & Society* (Jenkin et al., 2011) and a paper in *Business Strategy & the Environment* (Morhardt, 2010). In addition, a paper in *the Journal of Computer IS* (Molla & Abareshi, 2012) was excluded as this journal was not considered to be in the top eight IS journals, hence it was also excluded.

Quality was assured by narrowing the field to include only articles that had been published by scholars within the discipline's top eight journals with solid track records ranked according to impact factors. Not only were there precedents for doing this (Gholami, Watson, Molla, et al., 2016; Malhotra et al., 2013), but this would support a claim for rigour. The top eight journals, shown in Table 1 with their impact factor, were: *European Journal of IS*; *IS Journal*; *IS Research*; *Journal of AIS*; *Journal of Information Technology*; *Journal of MIS*; *Journal of Strategic IS*; and *MIS Quarterly* (Scholars, 2011).

Table 1: Basket of Eight Journals, in alphabetical order, showing impact factors.

Journal	Impact Factor
European Journal of IS	1.767
IS Journal	1.333
IS Research	2.01
Journal of the Association for IS	1.774
Journal of Information Technology	4.775
Journal of MIS	3.025
Journal of Strategic IS	2.692
MIS Quarterly	5.384

2.3.4 Data Extraction and Synthesis

Following quality assurance, the next stage of the process involved data extraction. For this a software programme, NVivo, was used, to code the papers in terms of theoretical frameworks, methodologies as well as the evolutionary category of the research. This continuum (Conceptualise, Analyse, Design and Impact) was based on a research-value classification from a previous search conducted over a six-year period elaborated earlier (Malhotra et al., 2013). This was further developed and identified as a spectrum illustrating increasing effectiveness in tackling climate change, depicted in Figure 4, from conceptualisation through analysis, to design and impact (Gholami, Watson, Hasan, Molla, & Bjørn-Andersen, 2016).



Figure 4: Potential value for tackling climate change (from Gholami et al., 2016).

Synthesis of this data was performed by the researcher with the goal of understanding emergent trends. Semantic word clouds created in NVivo assisted the researcher to understand the evolution of the field. These are illustrated in Figures 5 and 6.

The analysis of the papers in the first category (Conceptualise) shows the dominance of certain words in the papers. These words are “systems”, “sustainability”, “environmental”, “information”, and “properties”, illustrating the first attempts to describe Green IS using nouns. In contrast, the field changed to a more action-oriented research category with the Design category dominated by a discourse around “goal”, “activation” “act” change” “attribution” and bringing in stakeholders – “consumers”.



Figure 5: Word cloud for Conceptualise phase.

An attempt was made to identify the location of the authors within the sample, and this is shown graphically in Figure 7. The location of each author's affiliate university was considered for the spatial distribution analysis. It can be seen that there is a predominance of authors in North America and Europe, with German researchers in the lead. Noteworthy research is evident in Australia and South America. In contrast, there were no authors from Africa or Asia who have published in the top journals on the topic of Green IS. This represents an important gap to be filled.

Barriers to the publication of Green IS research have been explored (Gholami et al., 2016) and these include a paucity of data analysis in Africa and less support for researchers. It may be argued that first world countries, especially in Europe, America and Australia have better incentives alignment. For example, where policies are in place to limit climate change, funds become available to researchers. African countries have limited policies in place regarding climate change; hence there is limited funding available for researchers in the Green IS space.

In addition, similarities may be drawn between ICT for Development (ICT4D), and Green IS. Despite the best efforts of ICT4D implementations, constraints abound (Ojo, 2016). Bureaucracy, limited expertise and policy inertia have been identified as the major constraints to a case study of ICT4D implementation in Africa, and these issues may well be at play in the Green IS space. Another factor, competition with other issues, identified by Ojo (2016) as a constraint may also be valid. In Africa, there are many political and socio-economic issues which require urgent attention resulting in long-term issues like climate change being neglected. This is in contrast to authors who have noted that climate change is expected to have severe economic impacts, especially on rural farmers in Africa (Gbetibouo, 2009; Strydom & King, 2000) and therefore requires urgent attention.

A summary of the finding of the papers after the final screening appears in Appendix C, which shows the theoretical framework and the publishing journal as well as the main findings and gaps for future researchers. A brief overview of Appendix C is shown in Table 2, which illustrates the shortage of publications in the last two categories.

There were eight papers in the "Conceptualise" category, 11 in the "Analyse" category, one in the "Design" category and one in the "Impact" category, yielding a total of 21 Green IS papers in the Basket of Eight journals.

Table 2: Green IS articles sourced from Basket of Eight journals (extension of Gholami et al., 2016).

Conceptualise	Analyse	Design	Impact
Berthon & Donnellan (2011)	Bengtsson & Agerfalk (2011)	Corbett (2013)	Loock et al. (2013)
Butler (2011)	Benitez-Amado & Walczuch (2012)		
Dao et al. (2011)	Bose & Luo (2011)		
Elliot (2011)	Cooper & Molla (2016)		
Melville (2010)	Gholami et al. (2016)		
Pitt et al. (2011)	Hasan et al. (2016)		
Seidel et al. (2013)	Henfridsson & Lind (2014)		
Watson et al. (2011)	Hedman & Henningsson (2016)		
	Malhotra et al. (2013)		
	Marett et al. (2013)		
	Petrini & Pozzebon (2009)		

2.4.2 Conceptualise

The first author to galvanise the IS research community for environmental sustainability was Prof Nigel Melville of the University of Michigan, writing in *MISQ*, who conceptualised a research agenda and argued for the critical role that IS could play in enabling and transforming sustainable processes. Melville proposed a Belief-Action-Outcome model for what he called “*the new discourse in IS for environmental sustainability*” (Melville, 2010, p. 1). However, there are several critiques of this model. Sustainability, and by extension, its offspring Green IS, are complex problems which are by nature “wicked”, meaning they are not easy to solve. Melville’s Belief-Action-Outcome model (2010) may thus be too simplistic to explain a complex phenomenon such as Green IS. In addition, the model starts with a presumption of “Belief” yet provides no guidance on how Green IS beliefs are created. Drivers of such a belief system would add a layer of understanding to his model, but this was not done. There was also a lack of clarity on how to operationalise the model. The over-simplification of the complex issue of Green IS suggested that this was not an appropriate model to undergird development of the artefact in this study.

Melville’s seminal work was followed by researchers from the University of Georgia in the US and the University of Concepcion in Chile (Watson, Boudreau, Chen, & Sepúlveda, 2011). Their work was published in the *Journal of Strategic IS*, and they used the four information drivers of ubiquity, uniqueness, unison and universality as their underlying framework. While this was a useful lens, it

failed to explain how such a model was unique to Green IS as the constructs could apply to a range of different change management projects.

In 2011, for the first time, the phrase “Green IS” appeared as a keyword in the Journal of Strategic Information Systems (JSIS), in a special edition to welcome “The Greening of IT” (Berthon & Donnellan, 2011). These authors stopped short of making the connection to Green IS, hence their conceptualisation was not appropriate for this study. At the same time, in Australia, Steve Elliot at the University of Sydney was drawing together transdisciplinary perspectives using both a resource base and IT-enabled business transformation framework to shape his thinking. He noted in *MISQ* that although IT had the potential to address the challenges of environmental sustainability, it had not engaged researchers at the level needed to realise this potential (Elliot, 2011). Although his paper was insightful, the bias towards business made his model inappropriate for the Higher Education environment.

Meanwhile, authors from four countries (Canada, the US, Sweden and the UK) situated their work within the crisis discourse. They drew on U-Commerce for their theoretical framework and proposed a research agenda for the use of smartphones as integral parts of Green IS. They argued: *“Our world is in a state of environmental crisis – it is simply not large or rich enough in resources to sustain its current or future populations for very much longer in the manner to which many of its inhabitants have become accustomed”* (Pitt, Parent, Junglas, Chan, & Spyropoulou, 2011, p. 27). Despite this apt description, the focus purely on smartphones was identified as a limitation to their study, and hence not appropriate for the broader research topic of this thesis.

Another integrated sustainability framework was conceptualised at the University of Pennsylvania in the US using the resource-based view to develop sustainability capabilities (Dao, Langella, & Carbo, 2011). Although its contribution was useful, particularly the call for greater alignment, their focus on business made their framework inappropriate for the complex issue of sustainability in education.

A contribution came from Tom Butler at the University College Cork in Ireland where he proposed building theory on the role of Green IS (Butler, 2011). His framework included the influences of Green IS adoption, Green IS activities, and Green IS outputs outcomes, as shown in Appendix E. He drew on institutional theory to explain the drivers of Green IS, which he called regulative, normative and cultural-cognitive factors. He also used organisational theories to help explain how sense-making, decision making and knowledge creation enabled Green IS outputs. The use of institutional

theory is supported by Robey and Boudreau (1999) who have identified this as a valid perspective for IS researchers to investigate technologically-related institutional change. Support also comes from Orlikowski and Barley (2001) who called for researchers to draw on institutional theory to explore the regulative, normative and cultural-cognitive influences in the design and operation of IS. Given the strong backing of this particular theory, Butler's (2011) was ultimately selected as the theoretical framework to undergird the DSR artefact in this study.

2.4.3 Analyse

This section explores work of an analytical nature, including case studies, ethnographic analyses, quantitative, and qualitative empirical studies. Authors in this section hail from Australia, Canada, Chile, Denmark, Germany, Netherlands, Sweden, Switzerland, and the United States.

The urgency of this line of research was underlined by Gholami et al. (2016) who noted that the *"emergence of Green IS as an academic discipline is still ... far too slow relative to the needs of society"*. (Gholami, Watson, Hasan, et al., 2016, p. 521). They speculated on some reasons why this was so. Barriers to Green IS research, in their view, include incentives misalignment *"Only those IS scholars with an environmentally-active bent will research issues related to societal grand challenges without regard for traditional incentives"* (p525). Other reasons include the low status accorded to practical science in top journals; data shortages; and scoping issues. They recommended that *"Green IS strategically asserts itself as problem oriented ... our journals are full of theirs, but they create little value if they are only of interest to other IS researchers. We need to apply the theories we have"* (Gholami et al., 2016, p.529).

An assessment of analytical articles in this phase indicates a plethora of theoretical frameworks wrestled down into a variety of empirical realities. Authors drew on Actor Network Theory (Bengtsson & Ågerfalk, 2011); IT-enabled organisational capability (Benitez-Amado & Walczuch, 2012); economic theories (Bolívar, 2007); the integrative theoretical framework (Bose & Luo, 2011); absorptive capacity (Cooper & Molla, 2017); socio-technical systems (Erlinghagen & Markard, 2012); car usage model (Goebel, 2013); spatial decision support system framework (Gorsevski et al., 2013); activity theory (Gholami et al., 2016); strategy typology (Henfridsson & Lind, 2014); ecological efficiency and effectiveness (Hedman & Henningsson, 2016); organisational theories (Jenkin et al., 2011); energy informatics (Marett, Otondo, & Taylor, 2013); motivational theory (Molla & Abareshi, 2012); as well as grounded theory and sustainable scorecard (Petrini & Pozzebon, 2009) .

The diversity of frameworks suggest that during this phase, the Green IS stream of researchers was undergoing a profound paradigm shift rather than progressing in a linear manner, and that this “scientific revolution” of sorts, enabling new approaches to flourish (Kuhn, 2012). Whether this flurry of analytical activity was effective in furthering the impact of Green IS research, however, is a moot point as few of the authors in the subsequent phase (design and impact) tested these new theories.

While the contribution by authors to this genre of research is not in doubt, they may be critiqued for their reluctance to move beyond analysis. The questions arise: Why did these authors restrict their work to analysis? Why did they not use their considerable IS expertise to test their theories in practice?

2.4.4 Design

The article which fell into this category was based on the principles of DSR (Gregor & Hevner, 2013). It was posited that Green IS articles published in this space were of greater research value than papers which were more theoretical (Malhotra et al., 2013) since they hold a greater potential of leading to outcomes for tackling climate change (Gholami et al., 2016). A significant contribution to the field was made in Canada concerning the design, and use of Carbon Management Systems, which are a class of Green IS designed to persuade employees to develop sustainable behaviour (Corbett, 2013).

“A carbon management system supports the measurement and management of carbon footprints, which are defined as the quantity of GHG emissions (expressed in terms of carbon dioxide equivalent) released into the atmosphere” (Corbett, 2013, p. 345). Using three case studies and a positivist approach, she found that the key design principles for a Carbon Management System were integration with complementary programmes, tailoring of task support, and task reduction. This practical contribution has relevance for the current study as it also developed a Carbon Management System in an integrated way when interacting with stakeholders.

2.4.5 Impact

Finally, there was a category for impact-oriented research, which went beyond design to implementation, with the potential to create sustainability impacts (Malhotra et al., 2013). As can be seen in Table 2, this segment was under-represented in the top journals.

An important contribution was made towards understanding the motivation of energy-efficient behaviour with Green IS using default settings and goals (Loock, Staake, & Thiesse, 2013). Working in Switzerland and Germany, Loock et al. studied the role of IS in stimulating energy-efficient behaviour in households. They found that default goals for energy consumption led to statistically-significant savings. However, they found that default goal settings should not be too high or too low, as this would not motivate consumers. This work has received high recognition – as it was suggested that the work could be a *“potential accelerant to encourage green IS researchers to foster a community within and outside the IS scholarly community on this topic”* (Malhotra et al., 2013, p. 1271) because it provided a deeper understanding of the motivation of consumers to become more energy efficient, with the enabling power of Green IS. Loock et al. (2013) based their research on the extended model of goal-directed behaviour. If the current study considered behavioural change among staff this would have been appropriate, however, since it did not consider this aspect, default goals would not have been useful for incorporating Green IS into the curriculum.

2.5 Summary

Green IS as a research stream has gained traction since its inception 10 years ago. There appears to be a level of maturity in the literature, with 21 papers in the Basket of Eight IS journals. An apparent trend is the dominance of conceptual and analytical Green IS research in providing a foundation for more design-oriented approaches for developing IS artefacts that could have an impact on environmental sustainability.

This chapter critically evaluated the Green IS literature in the Basket of Eight journals, with a view to unearthing a theory to underpin the development of an artefact for incorporating Green IS into the curriculum. Most theories were considered inappropriate for a range of reasons, including the focus on business, and hence a poor fit with the Higher Education environment. Whereas some theories were considered too simplistic others were considered too difficult to operationalise. A model, which suggested the potential to be adapted for a DSR project, was Butler’s (2011) Green IS theory. It had its roots in both institutional and organisational theories, and as the DSR artefact was created in this context (a Higher Education institution) this particular lens was considered the most appropriate to refract the complexity of Green IS in the curriculum.

Regarding gaps identified in the literature review, there are two worthy of investigation. The first is the absence of Green IS research from Africa in the top journals. This gap has been identified through spatial analysis of top authors globally with a clear absence of authors from the continent. A

second gap that was identified was the shortage of design science and impactful research – again, this research is intended to contribute in this area. This will be a contribution to both theory and practice. In the following chapter, the extant literature within the sustainability education field is examined.

Chapter Three - In Search of Greener Pastures: Education Literature Review

3.1 Introduction

In the previous chapter, the nascent literature of Green IS was explored as a foundation for exploring how to integrate sustainability into the IS curriculum. However, an important leg of this project has not yet been examined. The key issue underlying this Design Science Research study is to find an appropriate pedagogy to underpin the integration of Green IS into the undergraduate curriculum. In this chapter, the nexus between education and the environment is clarified via an exploration of the extant literature. Curricular challenges in IS are examined, and the literature of sustainability in higher education as well as topics such as the pedagogical roots to problem-based and project-based learning are explored as possible modes of enhancing student engagement. The chapter also examines kernel theories in the change management literature, since some authors, have argued that the softer issues of organisational change such as values and philosophies need to be addressed via change management practices (Lozano et al., 2014). So, the potential for Green IS model under construction to become a change management process will be explored in the literature.

3.2 Drivers of Curriculation and Sustainability Issues

Curriculation has been described as *“an attempt to plan systematically and in an orderly fashion so as to bring into being effective design”* (Carl, 2009, p. 33). In the context of this study, which is about developing a model for the curriculation of Green IS, the focus on systematic planning and orderliness lends rigour to the process. Ultimately, the objective of this exercise is to synthesise recent research on Sustainability Education and find a way to incorporate it into the education of IS students.

This is a part of a zeitgeist towards making higher education increasingly relevant to social issues. Scharmer and Kaeufer (2013) have described education systems as having evolved through four stages, ultimately leading to what they call University 4.0, which offers students the most relevant learning experiences. They argue that the education system started in a traditional, authoritarian style (University 1.0). This needed to change to a focus on outcomes-based education (University 2.0) and later, in response to awareness of its stakeholders (University 3.0). In the most highly developed university (University 4.0) the focus is on co-sensing, presencing and co-creating, terms that will be defined later in this chapter. According to these authors, higher education has become

disconnected from the real needs of its students and society and becoming *“increasingly irrelevant to addressing the major global challenges of our time”* (Scharmer & Kaeufer, 2013, p.242).

Addressing the major global challenges of our time is, therefore, one of the drivers of curriculum change, and sustainability falls squarely in the ambit of these challenges. The issue of sustainability has been on the global agenda for 30 years since the idea was expressed at the United Nations that the current generation should be able to meet its needs without compromising the ability of future generations to meet their needs (WCED, 1987). The notion was underpinned by two interlinked concepts: the needs of the poor in society as well as the environmental needs of the planet. This entailed prioritisation of poverty alleviation (WCED, 1987).

The concept of sustainability embraced intra-generational equity, which means seeking fairness in society in the current generation, and inter-generational equity, which implies seeking justice between current and future generations (Mattioli, 2013). This additional layer of complexity has often been overlooked according to Steiner and Posch (2006) who argue that sustainability is a highly complex issue and consequently educating for sustainability is also complex. Traditional one-way educational processes are thus deemed ineffective (Steiner & Posch, 2006). This has support from Sauvé (2009) who critiqued the inadequacy of usual teaching practices for sustainability and proposed a focus on a holistic approach to sustainability education.

A link needs to be made between sustainability education and sustainability research as one informs the other; research on sustainability education helps create more aware teachers and more relevant curricula in a virtuous circle. The growth in the field of Sustainability in Higher Education, described as *“all research conducted within the institutional context of a university that contributes to sustainable development”* (Waas, Verbruggen, & Wright, 2010, p. 629), sees research as pivotal.

A review of the literature showed a number of critical attributes for students of sustainability, which can be categorised into four groups of assets: Foundational, Knowledge, Personal and Integrative (Viegas, 2016) as shown in Table 3. Each of these critical attributes or assets are described in turn and discussed with reference to issues in this study. The first four relate to the foundations of the intervention.

Table 3: Categories of critical attributes.

Category of Assets	Sub Category
Foundational	Philosophy
	Epistemology
	Interdisciplinarity
	Transdisciplinarity
Knowledge	Pedagogy
	Literacy
	Learning & Teaching
Personal	Values
	Beliefs
	Attitudes
	Behaviours
Integrative	Constructivism
	Complexity
	Holistic Thinking

3.2.1 Foundational Assets

Philosophy refers to ways of looking at the world (Viegas et al., 2016). For example, reformist sustainability philosophy requires a tinkering approach whereas transformational philosophy calls for more radical social changes (Hopwood, Mellor, & O'Brien, 2005). A third strand is eco-philosophy, which includes values, systems thinking and joint knowledge development (Hampson, 2012). However, the eco-philosophical approach has been slow to take hold.

Epistemology is rooted in ideas of what constitutes valid knowledge and how it can be acquired (Foth, Odendaal, & Hearn, 2007). Foth et al. call for research which is not restricted to hard science nor solely based on positivist epistemology but a model which values “soft” and contextual forms of knowledge. This has resonance within the IS discipline which takes a systemic view, seeing the world as a complex network of relationships. This “softer” perspective is more likely to yield deeper insights than the fractured reductionist approach which has been the dominant paradigm for nearly four centuries since Descartes (Capra, 1982).

Interdisciplinarity and *Transdisciplinarity* are the last of the foundational assets. *Interdisciplinarity* entails co-operation between disciplines, (Baumgärtner, Becker, Frank, Müller, & Quaas, 2008). It implies bringing together more than one field so that the complexity of a research topic can be understood more deeply than if approached through a single lens (Darbellay, 2015). In contrast, *Transdisciplinarity* transcends disciplinary boundaries and reconfigures disciplinary divisions into an integrated system. Transdisciplinarity is a method of research that brings a range of stakeholders together into the research project, united by a problem-solving perspective (Darbellay, 2015). This

problem-solving perspective is particularly relevant to this study as Green IS may be seen as a way of uniting multiple disciplines (for example, computer science and IS) into a research platform that attempts to solve intractable sustainability problems. The concept of incorporating problem-solving into the curriculum will be addressed in the next section.

3.2.2 Knowledge Assets

Moving on to the set of knowledge assets, three aspects were described – pedagogy, literacy, as well as learning and teaching (Viegas et al., 2016). *Pedagogy* refers to strategies for teaching, in other words, the “how” of teaching (Grant, 2012). Teaching strategies for sustainability must encourage self-reflection (Blanchet-Cohen & Reilly, 2013). This has support in the IS literature as Scott’s theory of coherent practice is rooted in reflexivity (Scott, 2012). On the other hand, if there is a rigid curricular structure the capacity for reflection (internalised learning) and reflexion (externalised and shared learning) is reduced (Viegas et al., 2016).

The next knowledge asset is described as *Literacy*. Students Sustainability Literacy is defined as “*having the understanding, skills, attitudes and attributes to take informed action for the benefit of oneself and others, now and into a long-term future*” (Diamond & Irwin, 2013, p. 339). It requires modification of curricula (Sidiropoulos, 2014; Waas et al., 2010) and is necessary as a strategy for systems thinking (Remington-Doucette, Hiller Connell, Armstrong, & Musgrove, 2013). According to Sterling and Huckle (2014), Education for Sustainability (EfS) is a *learning* approach based on critical thinking, reflection, building consensus and partnerships as ways of creating the ability of the learner to manage change. These competences will need to be evaluated in the final model. Sidiropoulos (2014) argues for the learner to be exposed to the values of sustainability, a notion that has support from other authors, who call for green values to be embedded in the design phase (Ijab, Molla, Kassahun, & Teoh, 2010).

Teaching, on the other hand, is about finding a range of methodologies for enabling sustainability literacy (Sidiropoulos, 2014). Indeed, around 15 years ago academics began grappling with the idea of a “sustainability science” which “*builds toward an understanding of the dual objectives of meeting the needs of society while sustaining the life support systems of the planet*” (Turner et al., 2003, p. 8074). This is evaluated in the model under the constructs of intra-generational equity (meeting the needs of society) and inter-generational equity (via sustaining the systems of the planet) (Luederitz et al., 2016; Mattioli, 2013; Steiner & Posch, 2006).

3.2.3 Personal Assets

There is also a range of personal assets which need to be included in sustainability education, including values, beliefs, behaviours, and attitudes. These sustainability assets are important to develop in students during their exposure to Green IS. According to Misselhorn (1998), *Values* might be defined as a set of principles which are used in making choices and play a role in influencing behaviour; *Beliefs*, however, are accurate or inaccurate assumptions about reality, and *Behaviour* is anything that students feel, think, or do. An *Attitude*, in contrast, may be described as a “*settled opinion or way of thinking*” (Allen, 1990, p. 70).

3.2.4 Integrative Assets

Finally, there are integrative assets – and these include Complexity, Constructivism and Holistic Thinking. Each of these will now be defined.

Complexity is, by its very nature, hard to define. It derives from the word “complex” which implies “*a network ... made up of related parts*” (Allen, 1990, p.233). It is not to be confused with the word “complicated,” as Gray (2009, p.1) avers: “*When you make the complicated simple, you make it better. But when you make the complex simple, you make it wrong*”. Perhaps complexity is best explained by way of example. Sustainability science, itself, has been conceptualised as a form of complex systems analysis (Wiek, Ness, Schweizer-Ries, Brand, & Farioli, 2012). The reason for this is that human and environmental systems are both vulnerable to environmental hazards that flow across the boundaries of both systems, including the storms of climate change, which wreak havoc on both nature and human communities. Political and economic forces as well as competing stakeholder positions add another layer of complexity. In addition, there is the temporal feature – the interconnectedness of past, present and future, as it is unclear how various climate change scenarios might unfold, based on human activity in the past and present. Sustainability scientists cannot solve these problems on their own, but require other elements including the policy, legal, technological and education systems for a collective understanding to emerge (Wiek et al., 2012).

Constructivism relates to the student’s activities to construct meaning (Biggs, 1996). Constructivist learning, therefore, implies that the design of curricula activities need to be undertaken which will help students make sense of sustainability in a meaningful way.

Holistic Thinking implies seeing the whole, global, interconnected problem of climate change (at local, regional, national and international levels) as opposed to dealing with it piecemeal. This is an

approach advocated by Giddens, who argues for a holistic approach in his book on the politics of climate change (Giddens, 2009).

The complexity of the problem of sustainability education expressed above, has led to various concerns such as how to find a learner-centered teaching strategy that drives student engagement and deep learning. These will now be discussed in detail.

3.3. Encouraging Engagement

In the quest to enhance engagement with students in sustainability education, the author explored a range of strategies in the literature. One such involved positioning the course within a particular problem, as opposed to starting with a purely theoretical approach.

Problem-based learning (PBL) is seen as a *“learner-centred approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem”* (Savery, 2006, p. 12). This is based on the pedagogical view that learning is a process in which a learner actively constructs knowledge (Gijssels, 1996). It is also described as focused, experiential learning centred around the investigation and resolution of intractable real-world problems (Torp & Sage, 2002). Furthermore, it is described as attempting to solve a problem that does not have a single correct answer (Hmelo-Silver, 2004). This entails students working in collaborative groups to clarify what needs to be learned, self-directed learning, application and reflection (Sterling & Huckle, 2014).

The roots of PBL can be traced back to Harvard Law School in 1870 and Harvard Business School which experimented with the method from the 1920s which used problems as learning tools (Servant & Schmidt, 2016). PBL evolved in the health sciences at McMaster University in Canada when they introduced the tutorial process, not only as a method of instruction but also for restructuring the curriculum to promote student-centred learning (Barrows & Tamblyn, 1980). There was evidence that the processes of activating prior knowledge occurs in tutorials where new knowledge arose during the course of discussing a relevant problem (Schmidt, 1993) in an informal setting, often by building on the students’ prior knowledge.

Activating prior knowledge has resonance in the literature, for example, Vygotsky’s zone of proximal development – this notion implies that students can move from the known to the unknown

(Vygotsky, 1978) from simple mental processes to higher order processes, such as problem-solving. If students can draw on their own experience or past learning, they have a foundation for new learnings.

Skills which may be developed include the ability to think critically, analyse and solve complex, real-world problems, to find, evaluate and use appropriate learning resources, to work cooperatively, to demonstrate effective communication skills, and to use knowledge to become lifelong learners (Duch, Groh, & Allen, 2001). This is corroborated by Wiek et al. (2015) who have identified key sustainability competences including interpersonal competences.

According to Savery, there have been apparent successes of PBL in producing graduates with a range of attributes required by employers. These include *“high level skills in communication, computation, technological literacy, and information retrieval that would enable individuals to gain and apply new knowledge and skills as needed... the ability to arrive at informed judgments by effectively defining problems, gathering and evaluating information related to those problems, and developing solutions; the ability to function in a global community; adaptability; ease with diversity; motivation and persistence (for example being a self-starter); ethical and civil behavior; creativity and resourcefulness; technical competence; and the ability to work with others, especially in team settings”* (Savery, 2006, p. 17).

PBL is supported by others (Bruner, 1971) who argue that exploring a problem leads to the intrinsic motivation which encourages students to learn more about a topic when there is no external reward in sight (such as passing a test or obtaining a qualification). It is referred to as epistemic curiosity (Schmidt, 1993). Other eminent educationalists confirm the view that PBL encourages student curiosity (Biggs, 1999). Biggs goes so far as to say that students who are genuinely interested in their studies are more likely to enter the learning process with high levels of engagement. He describes these as explaining, relating, applying, and theorising. In contrast, other students who do not have a *“driving curiosity about a particular topic”* (Biggs, 1999, p. 57), have a superficial interest, only wanting to pass. They adopt a surface approach to learning (Marton & Säljö, 1976) and their level of engagement is at the level of note-taking.

However, a challenge for lecturers is that they need to transform themselves from being knowledge providers to facilitators. *“The reality is that learners who are new to PBL require significant instructional scaffolding to support the development of problem-solving skills, self-directed learning*

skills, and teamwork/collaboration skills to a level of self-sufficiency where the scaffolds can be removed” (Savery, 2006, p. 15).

Initially, it was merely conjecture that the PBL approach was more engaging than traditional methods. This led to 20-year analysis which found PBL to be more nurturing and enjoyable for both students and staff (Albanese & Mitchell, 1993). Furthermore, outcomes such as faculty attitudes, student mood, class attendance, academic process variables, and measures of humanism scored well, supporting the view of the superiority of PBL (Vernon & Blake, 1993). This is corroborated by other studies which have found PBL to provide effective ways of solving unstructured problems with the lecturer as a coach, thus transferring learning responsibility to the student (Denton, Adams, Blatt, & Lorish, 2000).

However, PBL is not without its critics. To be balanced, it is important to note that it can be seen to undermine more open-minded, knowledge-centred learning (Bereiter & Scardamalia, 2000). In addition, in some cases, PBL students scored lower and perceived themselves to be less well prepared than conventionally-trained graduates (Albanese & Mitchell, 1993).

Hence, PBL should not be seen as a panacea that can solve all issues related to sustainability education. It may be appropriate in cases where students have the opportunity for personal growth in terms of their ability to articulate an engaged understanding of a specific problem, which is relevant and meaningful for them. However, it may not be appropriate where specific technical or theoretical knowledge needs to be learned, for example, formulae related to carbon footprints and globally-agree protocols surrounding this. In other words, contextual learning may have its place, however, context-free data may be best taught (and learned) in a more traditional manner. On this note, it is appropriate to consider how to address another concern – how to encourage depth in the learning process for sustainability.

3.4 Encouraging Deep Learning for Sustainability

Student learning research began in Sweden with Marton and Säljö's (1976) studies of deep and surface approaches. A deep approach implies an active attempt by the student to understand new concepts and relate them to existing knowledge. In contrast, the surface approach involves memorising facts in anticipation of the need to regurgitate them during assessment (Marton & Säljö, 1976).

A real desire to understand and genuine engagement with the topic, rather than merely passing an assessment, appears to be at the heart of what distinguishes deep learning from surface learning. There has been some debate in the literature about these two approaches, with Biggs (1996) finding a particular failing among undergraduate science students to engage in deep learning. He argues that there are two lines of thinking in higher education – one is drawn from constructivist learning theory and the other from instructional design. The former implies a focus on the learner's activities in constructing meaning (Biggs, 1996). This has important implications for curriculum design because activities need to be developed which will fully engage the students. For example, if a project management course is designed to allocate most of the marks to the practical component rather than the exam it is likely to encourage deep learning. However, if it is designed with multiple-choice assessments students will focus on memorising facts and engage in surface learning.

Ramsden (1997) argues that if students are provided with good teachers, support and a choice of study methods they are likely to adopt deep learning strategies with high engagement. Reasons for students adopting surface approaches have been advanced, with some authors arguing that an excessive amount of theory pushed onto students may be to blame (Entwistle & Ramsden, 2015). Warburton (2003) contends that students who have adopted surface learning strategies may not engage with complex sustainability-related issues. He argues that a priority for educators must be to provide an environment where students develop a strong personal interest in sustainability issues. He adds that introducing relevant sustainability issues into existing courses may be valuable, especially if they encourage critical thinking, problem-solving decision-making, and conflict resolution.

There are many useful principles for encouraging deep learning in sustainability education. Deep learning can be assisted by encouraging discovery learning which is self-directed with the teacher as a facilitator (Rogers & Freiberg, 1994). It can also be encouraged by dealing with a real-world issue in which concepts are clearly explained. Warburton (2003) adds that all learning should be a discovery process, rather than being presented with a set of facts. This is supported by Hounsell (1977) who proposes essay writing as a tool for the students to construct a logical argument based on data as a deep approach that encourages active engagement (Hounsell, 1997). The meaning of abstract ideas will thus emerge organically (Warburton, 2003).

It must be borne in mind, however, that deep learning may not be desirable in all situations. In the early stages of sustainability education, other approaches could be more appropriate as a way of

introducing students to the topic. For example, the use of social media such as Facebook can become a tool for informal sustainability education via quizzes, lectures, and assignments as this meets the need of students to be connected and develop social capital (Qureshi, Raza, & Whitty, 2015). Gamification including customised motivational strategies, feedback tactics and competitive games, could also be *“an important step toward the advancement of Green IS, which are dedicated to the convergent consideration of technology, people, data and processes by enabling simultaneous tracking and management of environmental objectives”* (Klett & Wang, 2015, p. 353).

Having examined some of the concerns related to deep and surface learning, it is now appropriate to situate the literature review within the specific context, which is the IS undergraduate curriculum and explore a range of problems that exist there.

3.5 Curriculation Challenges in IS

At this point, it is appropriate to examine the literature related to the particular challenges facing the IS discipline in terms of curriculum content. The development of a comprehensive undergraduate curriculum has seen three major revisions for recommending a formal body of knowledge for undergraduate degrees (Topi et al., 2010). This ongoing process of revision and reflection is important for the IS discipline due to its complexity as it addresses not only technological and social systems, but also the phenomena that emerge when the two systems interact (Lee, 2000).

Given the constant demand by industry for IS graduates, departments need to continuously ensure that their courses and curricula remain abreast of new and evolving changes (Janicki et al., 2014). For example, job survey data shows that there is an increasing demand for project managers and IS academics need to meet this growing need. According to a recent survey the job category of Project Management grew by 32% in 2013 and by 27% in 2014, and this skill is considered important for future IS professionals (Janicki et al., 2014). Data suggests that the need still exists in 2017 with IT Project Managers in South Africa earning on average R420 000 per annum increasing to R850 000 per annum for top earners (Payscale.com, 2017).

A further issue to consider is that the IS discipline is positioned in a highly dynamic world of constant technological change. This fast pace of technology change reshaping the workplace motivates educators to improve curricula constantly. (Legier, Woodward, & Martin, 2013). In effect, there is a constraint against incorporating sustainability into the curricula as the IS content must be designed

to cover the increasing technological knowledge base which crowds out innovations such as Green IS courses. For example, the rise in ethical issues in the IS domain has led to calls for legal and ethical issues to be incorporated into the curriculum (Wayman & Kyobe, 2012). Hence, there is competition for space in the programme taking into account the relentless growth of technology and other issues. In effect curriculum developers battle to balance courses comprising technical experience, management theory, IS strategy, communication skills, and other issues within a finite number of IS courses (Janicki, Fischetti, & Burns, 2016).

A revision of the IS undergraduate curriculum came about due to changes not only in technology but also in industry, including globalisation, the introduction of web technologies, mobile computing and other issues. The latest curriculum was also an attempt to reverse the trend of decreasing enrollment by undergraduates in IS degrees (Topi et al., 2010). The revision also specified underlying principles, which should inform student interventions. However, as they did not specify integrating Green IS into the curriculum this remains a gap. The guidelines called for graduate attributes and competences, which could be applied to sustainability education. These include:

“IS professionals must have strong analytical and critical thinking skills to thrive in a competitive global environment. Students must, therefore:

- be problem solvers and critical thinkers,*
- use systems concepts for understanding and framing problems,*
- be capable of applying both traditional and new concepts and skills,*
- understand that a system consists of people, procedures, hardware, software, and data within a global environment.*

... IS professionals must exhibit strong ethical principles and have good interpersonal communication and team skills. Students must understand that IS professionals should be able to:

- critically evaluate and possibly act on current ethical issues in the IS field,*
- apply professional codes of conduct,*
- collaborate with other professionals as well as perform successfully at the individual level,*
- communicate effectively with excellent oral, written, and listening skills,*
- demonstrate persistence, flexibility, curiosity, creativity, risk-taking, and a tolerance of these abilities in others.*

... IS professionals must design and implement information technology solutions that enhance organisational performance” (Topi et al., 2010, p. 8).

All of these apply to the Green IS curriculum as they challenge students to develop competences that are necessary for solving sustainability problems in a collaborative way.

However, other authors point to the tardiness of the discipline to embrace curriculum change. For example, Wayman and Kyobe (2012) argue that although a continuous review of curricula is crucial, there are a number of reasons for reticence to change, including the need for a better understanding of the purpose of integrating relevant issues. The Wayman and Kyobe (2012) study showed that curricula development in South African universities was heavily influenced by the department policies, possibly due to the historical development of the departments, which were often based on United States models with little African contextualisation.

The challenges described by IS curricular development provide the background as to why incorporating Green IS in higher education is a complex and challenging task. In addition, there is the challenge of student engagement. Arguments have been made that if the student experience is more engaging, it is likely to lead to better learning outcomes (Bryson, 2016) which provide a further layer of complexity. All of these factors including the challenges of curriculum change motivate a different approach to teaching and learning, compared to the traditional modes of instruction.

3.6 Problem-Based Learning versus Project-Based Learning

Student engagement alluded to earlier, can be enhanced with learner-centred instructional patterns of which one strategy is project-based learning (Savery, 2006). This method has been described as a range of learning activities focused on a particular dominant purpose (Kilpatrick, 1918). Indeed, the history of the educative role of the project method has a long history in education. Project work at architectural schools in Europe, which began in the late 1500s, has led to the globalisation of the project idea (Knoll, 1997). Complementary to this method is problem-based learning (Albanese & Mitchell, 1993) where the focus and stimulus of student activity is a particular problem often of unstructured and multi-disciplinary in nature (Boud & Feletti, 1991). The author will now explore how both problem- and project-based learning can be harnessed to achieve sustainability objectives that tend to arise from unstructured problems and require multi-disciplinary solutions.

3.7 Problem- and Project-Based Learning for Sustainability

The education for sustainability literature has endorsed Problem- and Project-based learning (PPBL) as a relevant strategy. PPBL is often outcomes-based, meaning that its goal is to provide practical

solutions to sustainability problems (Wiek et al., 2012). Accordingly, universities have begun to offer PPBL courses to meet this need. Some researchers have argued that there is a range of commonalities between problem-based and project-based learning as illustrated in Table 4.

The common ground includes student engagement with real-world issues, student-centredness, the role of the lecturer as guide, and small group work. In contrast, the two types of learning differ in terms of outcomes, the main activity, organising principle, and a measure of self-directed learning, as depicted in the table below. For example, problem-based learning is intended to develop a deeper understanding and theory building around an unstructured problem, whereas project-based learning can lead to a specific understanding of a particular case, and hence surface learning. The value of combining the approaches it thus likely to lead to both outcomes.

Table 4: Problem-Based and Project-Based Learning, based on Brundiers & Wiek (2013).

Problem-Based Learning	Commonalities	Project-Based Learning
<i>Outcomes:</i> Deeper understanding	Students engage in real-world tasks	<i>Outcomes:</i> Case-specific understanding
Theory building	Student-centred	Practical products
<i>Main activity:</i>	Simulate professional situation	<i>Main activity:</i>
Problem situation enquiry	Process multiple data sources Teacher as facilitator and resource guide	Producing applicable results
<i>Organising principle:</i>		<i>Organising principle:</i>
Learning tutorial	Formative and performance-based	Project management
<i>Self-directed learning:</i>	Evaluation	<i>Self-directed learning:</i>
Fully student-centred in loosely predefined setting	Small group work	Student-centred within predefined Project frame

Despite the value of PPBL in encouraging student engagement with sustainability and its endorsement by senior scholars (Brundiers & Wiek, 2013) it is not without its critics. For example, the dominance of the problem and project may lead to a loss of solid theoretical foundation provided by more conventional methods of instruction. In addition, there is a danger of failing to achieve learning outcomes if inappropriate assessment methods are used (Boud & Feletti, 1991).

Having explored PPBL as a potential learning strategy for Green IS attention now needs to be paid to the skills and competencies that would be required for graduates of the programme.

3.8 Competence Development

The notion of competence development has its roots in skills acquisition according to Dreyfus and Dreyfus (1980) who describe a highly-structured process for guiding the personal growth of an individual from novice (who follows the rules) through five phases until mastery (the highest level of expertise and intuition) is attained. However, this has been critiqued by other authors who, for example, argue that there is no empirical evidence for the presence of these five stages (Gobet & Chassy, 2009).

An alternative model is provided by Cockburn (2002) who describes three stages of learning for software development. As this process has already been accepted within the IS education domain, it is worthy of consideration. Cockburn's model draws on ancient martial arts traditions from Japan based on a sequence of three elements – Shu, Ha and Ri - which lead a student down a path of learning starting with imitation (Shu), followed by a point of reflection (Ha), and ending in innovation (Ri) (Fox, 1995).

In “Shu”, the student builds the technical foundation with a loyal persistence to the instructor, copying techniques in the “Follow” phase. As a starting point for software programming, this has support in the literature (Bruce et al., 2006) as it is important for developers first to learn the rules and follow what has been done before. The next step is called “Ha”, which means to detach and break free. In the Ha stage, the student must reflect deeply, as opposed to merely following instructions (Fox, 1995).

The third stage is “Ri” meaning to go beyond or transcend. At this stage, the student has developed mastery over the subject and uses background knowledge as well as original thought (Fox, 1995). Cockburn (2002) likens this to becoming fluent in a foreign language hence he terms this the “Fluent” stage. It is this kernel theory of three stages of software development – Follow, Detach, Fluent – which was selected as an underlying theory to be developed during the research project as recommended by DSR leading proponents (Gregor & Hevner, 2013).

Organisations focus much of their sustainability efforts on “hard” techno-centric issues (Lozano, 2013) yet few have successfully institutionalised sustainability into their systems and cultures (Siebenhüner & Arnold, 2007). To fill this gap, a new body of literature has emerged that focuses on the social barriers to sustainability within organisations (Ceglia, de Abreu, & Da Silva Filho, 2016).

This body of work emphasises change theories for dealing with the “soft” human issues by comprehensively addressing visions, leadership, principles, goals, mindsets, teams, communication, innovation rewards and aligning systems to sustainability (Doppelt, 2009). Over time these have been well developed into a range of key sustainability competences including interpersonal, anticipatory, normative, systems thinking and strategic competences (Wiek et al., 2015). These soft skills have been identified as some of the outputs of sustainability transition experiments (Luederitz et al., 2016).

Building on Cockburn’s (2002) three-step process the author sought further insights from the change management literature. Despite theoretical guidance, many organisations find change a formidable issue as it requires continuous and iterative attention (Pettigrew & Whipp, 1993). In addition, a major constraint is the unwillingness of people in an organisation to accommodate change with tactics ranging from reticence to overt or covert battles over resources (Lewin, 1947). In fact, Lewin is credited with developing one of the earliest models of change based on the concept of an ice block, which is frozen and needs to be unfrozen before it can be refrozen. This model has received criticism from some authors who argue that the linear model (unfreeze-freeze-refreeze) is overly simplistic (Batras, Duff, & Smith, 2016).

Searching within the change management literature and looking for midrange theory (neither overly simplistic nor overly complex) the author identified a candidate theory in the change management literature known as “Theory U” (Scharmer, 2007). It involves a multi-stage process following a U-shaped curve (Scharmer & Kaeufer, 2013). This has at its crux (the lowest part of the “U” shape) a concept called *presencing* – a reflective space where individuals and groups detach, reflect deeply, and begin to operate from a sense of future possibilities. This process of reflecting (similar to Cockburn’s “Detach” element) could prove valuable if incorporated into the Green IS curriculum as it would enable students to develop *normative competence* (assessing the present), as well as *anticipatory competence* (being able to anticipate future scenarios) (Wiek et al., 2015). Scharmer and Kaeufer (2013) describe it thus: “*The word presencing merges the terms presence and sensing. It means to sense and operate from the presence of an emerging future field. As we connect with this field of heightened awareness, our attention morphs from slowing down, opening up, redirecting, and letting go to letting come, crystallizing, and embodying the new*” (Scharmer & Kaeufer, 2013, p.29). In the Netherlands, for instance, this theory has been built on action research (Glasl & de La Houssaye, 1975). It is the construct of presencing that is significant for Green IS students as it concerns the ability to envision the future. This aligns with an important competence described in

the sustainability literature as anticipatory competence, described by Wiek et al. (2015) as the ability to anticipate a future scenario.

Theory U has the backing of other learning experts including the author of the *learning organization* (Senge, 1990). The theory is used in the change management literature (Cameron & Green, 2015) as well as by education for sustainability experts (Sterling & Huckle, 2014). However, it is not without its detractors. Warrilow (2017), for example, is critical of Theory U which he says lacks originality. *“There is nothing new in the idea of a creative thought and action process based around mental stillness, active listening, reflection, emergent intuitive ideas, and driving an initiative through an iterative process of successive prototypes ... in my view the originality may lie in applying this in a group context and a business environment”* (Warrilow, 2017, p.1).

3.9 Summary

The purpose of this chapter was to review the literature within the domain of Education for Sustainability through examination of the extant literature in this area with a view to sourcing a theoretical framework to guide the development of the artefact. In this process, the author addressed a range of concerns including the need to involve learners in deep learning processes and to find ways to foster engagement with Green IS. Ultimately, an argument was made for students to become involved in Problem- and Project-based Learning as a useful pathway to develop key sustainability competencies. Some of the drawbacks of deep learning and problem-based learning were also highlighted, as these objectives are not appropriate in all circumstances.

The author also examined some of the problems related to curriculum change within the IS undergraduate programme. These included competition between the need to keep the curriculum abreast of relentless technological changes and the need to be relevant to new and important topics such as Green IS.

The search for a model for creating real change in the lives of students led first to the software development literature and then to the change management literature. Theory U was found to introduce the construct of presencing as a key process for students needing to develop normative competence (analysing the present) and anticipatory competence (anticipating the future).

Having examined the extant literature related to education for sustainability, the stage has been set for the next chapter, which will set out the author's search for the most appropriate methodology to address the research problem.

Chapter Four – Research Approach

4.1 Introduction

While the previous chapters set the foundation for this thesis by exploring the literature of Green IS and sustainability education, this merely set the stage for the DSR project implementation. It then became important to choose a relevant methodology to address the research problem, which it will be recalled, is the absence of Green IS in the undergraduate curriculum.

The starting point of this chapter is to examine the various approaches that are available to the IS academic community as paradigms which undergird enquiry. After selection of the most appropriate paradigm, key elements of the approach are outlined. Furthermore, alignment with the international standard for carbon footprinting, namely the Greenhouse Gas Protocol Methodology, is discussed and the chapter ends with data collection and ethical considerations.

First, the author briefly describes a range of competing paradigms and makes a choice which links in a logical way to the research problem of the study. It is important to note that this research is intended to lead to the development of prescriptive theory, namely how to incorporate Green IS into the curriculum.

4.2 Paradigm Choices

Researchers refer to the “incommensurability of the paradigms”, meaning that the basic beliefs in each view on how knowledge is created cannot always logically be accommodated by a competing paradigm (Guba & Lincoln, 1994). This does not mean that the researcher needs to make a distinction between qualitative and quantitative choices as this argument suggests: *“From our perspective, both qualitative and quantitative methods may be used appropriately with any research paradigm. Questions of method are secondary to questions of paradigm, which we define as the basic belief system or worldview that guides the investigation, not only in choices of method, but in ontologically and epistemologically fundamental ways”* (Guba & Lincoln, 1994, p. 105).

Traditionally, there were four paradigms for guiding inquiry in the social sciences that have been described as positivism, post-positivism, critical theory and interpretivism (Guba & Lincoln, 1994).

However, more recently authors within the IS discipline have staked a claim to others, including the Design Science Research paradigm (Gregor & Hevner, 2013), also known as DSR.

Historically, *positivism* was the dominant worldview in the hard sciences such as Mathematics, Physics and Chemistry. In the early days of IS, this was also the most common approach. Positivists view knowledge as a set of verified hypotheses, which can be regarded as facts or laws. Knowledge accumulates through accretion. In essence, positivists follow Karl Popper's distinction between science and myth – with the test for a positivist theory being whether or not it can empirically be shown to be wrong (Kuhn, 1970). New data may lead to a theory proved invalid. However, some IS scholars have argued that positivism should be seen as one of many tools (Straub, Boudreau, & Gefen, 2004) while others go further and call for a broadening of the scope of enquiry (Robey, 1996; Walsham, 1995). Positivism has been critiqued in the social sciences for over-simplifying causal relationships. Implementations of IS, for example, do not necessarily lead directly from cause to effect due to a multitude of unintended consequences (Ciborra, 2002). The phenomena that emerge when people and technology interact cannot always be easily explained by positivists (Maxwell, 1998).

Postpositivists, on the other hand, while seeking objective truth, believe that knowledge is not based on solid foundations but mere conjectures. They hold that knowledge can be justified by a set of warrants, or justifications, which may change over time. Thus their ontology assumes that reality exists but can only be known imperfectly (Zammuto & O'Connor, 1992).

In contrast, some IS researchers have positioned their studies within the *interpretivist* tradition (Klein & Myers, 1999; Walsham, 1995). This stance is relativist in its ontology (Burrell & Morgan, 1979) meaning that knowledge is socially constructed. The goal of an interpretivist scientist is to enrich understanding of human actions (Chua, 1986).

A *critical* scientist, on the other hand, adopts an overtly confrontational style. She sees the goal of her research to identify and remove “*an oppressive ideological practice*” (Chua, 1986, p. 622) via critical discourse analysis or other tools. This may have been a useful approach had the study dealt with a question, such as: “Why is an institution of Higher Education slow to apply sustainability across all its operations?” However, this question is beyond the scope of this enquiry and best left for future researchers. Hence this underlying philosophy is not appropriate for this particular study.

Finally, a number of IS academics have made a claim for *DSR* to be seen as a fifth paradigm in the discipline (Gregor & Hevner, 2013; Hevner & Chatterjee, 2010; Hevner, March, Park, & Ram, 2004). They argue for its acceptance as a legitimate research approach within the discipline on the basis that it brings the rigour, which is required to underpin the creation and evaluation of artefacts which are part of solution-building research (Woo, Saghafi, & Rosales, 2014).

In essence, they argue that DSR includes the creation of “*a wide range of socio-technical artefacts such as decision support systems, modelling tools, governance strategies, methods for IS evaluation, and IS change interventions*” (Gregor & Hevner, 2013, p. 337). They posit that a challenge exists for IS researchers to present their work in such a way that reviewers can clearly see the knowledge contribution. This is due to the “*comparatively recent recognition of DSR as a distinct, yet legitimate, research paradigm*” as well as the youth of IT disciplines themselves, compared to, say, the natural sciences which matured during the 18th Century (Gregor & Hevner, 2013, p. 338). This is consistent with authors who note that the IS field needs more solution-building research (Woo et al., 2014). Support also comes from Walsham (2012) who laments the fact that Design Science is not part of the curricula in PhD programmes and contemplates that it will be “*even more important in the future*” (Walsham, 2012, p. 4).

In order to follow a rigorous scientific method there are seven requirements for DSR (Hevner et al., 2004). These are as follows:

1. The *design of an artefact* as a research output, addressing an important problem.
2. The problem should be *relevant* to the academic community.
3. The design requires *evaluation* on a range of criteria.
4. The researcher needs to identify clear *contributions* to knowledge and practice.
5. The research should be *rigorous* – with rigour applied to both the creation of the artefact and its evaluation.
6. An iterative *search process* for the design should be demonstrated.
7. The research findings should be *communicated* to a wide audience.

In the final chapter of this study, the author will argue and provide evidence that each of these requirements has been met.

4.2.1 Kernel Theories

Having adopted DSR as an appropriate paradigm, it is instructive to examine key elements that are necessary for the approach. Design Science offers researchers a unique way of looking at the world.

Hevner et al. (2004) propose that the rigour of DSR is determined from the use of prior research, which guides the innovation process. Gregor and Hevner (2013) describe these as *kernel theories*, meaning they are reference theories, often drawn from other disciplines. A kernel is defined as “*the whole seed ... nucleus or essential part of anything*” (Allen, 1990, p. 647). Figuratively speaking, then, a kernel theory is the seed or the DNA or the centre of the development of a DSR artefact. It is at the very heart of the innovation. A new artefact utilising DSR needs to draw on kernel theories, or seeds, to inform the innovation. The word kernel implies being essential to the innovation. Some researchers describe the process of theory-making in design as “*synthesizing elements of kernel theories*” from other fields which are helpful in constructing prescriptive knowledge (Walls, Widmeyer, & El Sawy, 1992, p. 41). This is consistent with experts who argue that the results of DSR must be related to existing knowledge bases to ensure that they are “*well-founded and original. It is not sufficient to just produce some knowledge; the new knowledge also has to be integrated with previous knowledge in the area and shown to provide novel insights*” (Johannesson & Perjons, 2014, p. 61).

The kernel theories for this study originated in two domains. The first is the Green IS theory, which was devised by Butler (2011) and identified as a theoretical framework in Chapter 2. The second is the change management theory described as Theory U, which was innovated by Scharmer (2007) and identified as a kernel theory in Chapter 3.

4.2.2 Ontology

In addition, DSR needs to have a solid ontological base. An argument has been made that design science relates to products of human social action including IT artefacts (Iivari, 2007). This evokes the question of how to define such artefacts. Senior scholars have described IT artefacts as “*bundles of material and cultural properties packaged in some socially recognizable form such as hardware or software*” (Orlikowski & Iacono, 2001, p. 121). This concept has been expanded by other researchers to include a progression of elements from constructs to models and methods, and ultimately to instantiations (March & Storey, 2008).

Building on this, Iivari identifies seven roles of IT applications which he says are to “*automate, augment, mediate, informate, entertain, artisticize or accompany*” (Iivari, 2007, p. 43). The role to *informate* is a process that translates data into information, which becomes meaningful to an organisation (Zuboff, 1988) and it is this role of informing Green IS which will be explored in the thesis. It is only when a plethora of data including electricity, waste, commuting and other issues are

carefully analysed via Green IS that the organisation can make sense of them. Hevner supported livari and took the argument further by positing the need for intersecting cycles of relevance, rigour and design (Hevner, 2007) as was illustrated in Figure 2.

4.3 Design Science Considerations

Since the main deliverable of this thesis is an artefact that makes a contribution to practitioners, it is appropriate to consider issues related to its development as well as the theoretical elaboration aligned to the new model. Design Science can be categorised as producing either prescriptive or descriptive knowledge (Mokyr, 2002). Prescriptive knowledge involves practical knowledge of how to develop human-created artefacts while descriptive knowledge concerns more theoretical knowledge. The former encompasses constructs, models, methods, and instantiations (including systems and products or processes) as well as design theory. On the other hand, descriptive knowledge is more theoretical and includes phenomena and sense-making. The two knowledge bases are interconnected, as descriptive knowledge contributes and informs prescriptive knowledge, and vice versa (Gregor & Hevner, 2013). This research project concerns the development of a prescriptive model, specifically the development of a model for incorporating sustainability into the curriculum. Thus, the choice of DSR is an appropriate choice of paradigm for developing prescriptive theory, and the process of development provides useful subject matter for exploratory studies.

Another methodology considered by the author was the case study. There is a solid history of case study research in the IS discipline (Klein & Myers, 1999; Lee, 1989; Markus, 1983; Ngwenyama & Nielsen, 2014; Walsham, 1995) and it could have enabled the development of a rich theoretical framework. In addition, a case study presents would have enabled ,meaningful insights to be extracted from a specific context within its real-life context (Yin, 2014). This form of empirical enquiry would clearly have been a useful process, especially since the author focused one a single case as the context of her study. However, a major flaw in this methodology is that it focuses on a contemporary phenomenon and the author wanted to not only examine what currently exists, but also investigate “*how things ought to be*” (Simon, 1996, p. 114). As the author needed to explore the problem of the lack of Green IS teaching and learning, it was decided that DSR offered the greatest scope for not only developing a theoretical framework but also for providing a possible solution to the problem of the absence of Green IS in the curriculum.

The author also considered the possibility of including action research in the project as an argument could be made for developing each iteration of the process as an action experiment. However, there

are several issues that mitigated against the selection of action research. Firstly, some researchers confuse design science and action research as both approaches involve problem-solving interventions and evaluation processes (Jarvinen, 2007). However, as Baskerville (2008) argues, design science is focused on problem solving by creating an artefact in a particular context whereas action research focuses on problem solving through organisational change. He also argues that design science explores discovery through design, whereas action research uncovers discovery through action. He states that action research is a methodology while design science is a paradigm (Baskerville, 2008). This is supported by Ivori (2007) who argues that design science be seen more broadly, as a research paradigm rather than a research methodology. Ivori adds that it is the rigour in creating IT artefacts, which are key in DSR as opposed to the construction of IT artefacts by practitioners outside the research community. The difference lies in evaluation – DSR requires scientific evaluation whereas inventions via action research do not (Ivori, 2007). In fact, Nunamaker, Chen & Purdin (1990) make a similar point, proposing a research method for constructing artefacts that includes theory building, experimentation, observation and systems development. However, the method proposed by Nunamaker ET AL. does not indicate how theory is linked to the other processes, nor does it include evaluation as a vital element. For this reason, this method was not adopted.

Instead, the publication schema for a DSR study proposed by Gregor and Hevner (2013) has been employed as the blueprint as it lends rigour to the study. Gregor and Hevner's (2013) prescription is comprehensive, detailing the following sections: introduction, literature review, method, artefact description, evaluation, discussion and conclusions. This framework has been used to build the chapters for this thesis. The author will now position this study in terms of the Knowledge Contribution Framework designed by Gregor and Hevner (2013) shown in Figure 8.

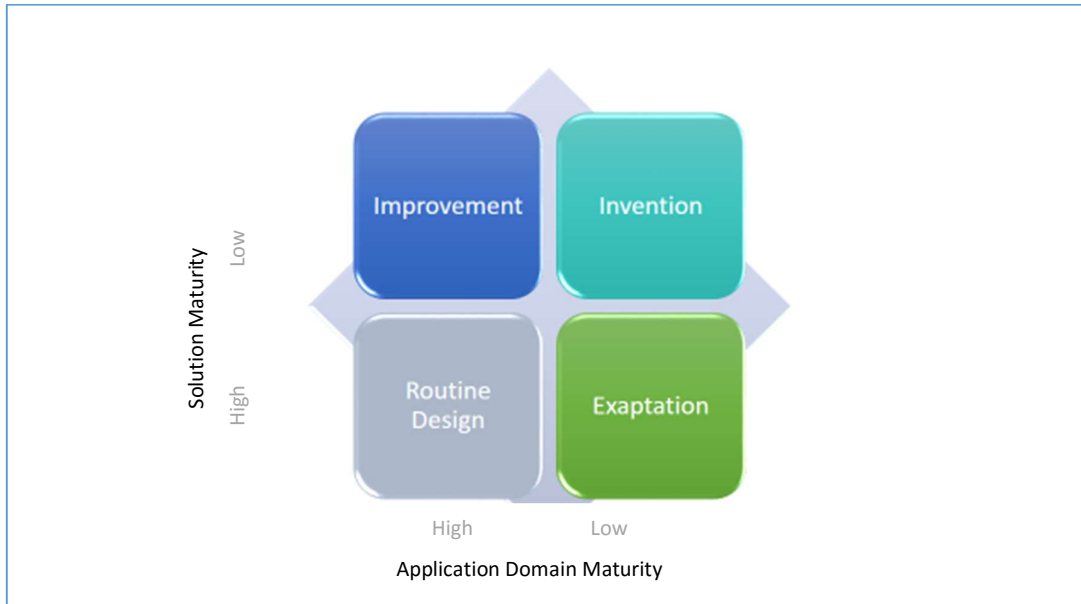


Figure 8: DSR Knowledge Contribution Framework (Gregor & Hevner, 2013).

Routine Design, in the bottom-left quadrant, offers known solutions to known problems with no major knowledge contribution, as there is high solution maturity as well as high domain maturity. However, as the solutions to sustainability problems such as Green IS integration are not known, and the domain is not mature, this study goes beyond this type of solution.

Improvement, shown in the top-left quadrant, develops new solutions for known problems. Sustainability may be described as a “wicked problem” meaning that it is not clearly defined or structured. The use of the word “wicked” refers to the formidable nature of the problem. As sustainability is neither clearly defined nor structured, the problem could not be described as “known”, therefore this study would not be appropriate for this quadrant.

The third quadrant, illustrated in the top-right quadrant is described as *Invention*. This involves inventing new solutions for new problems. The level of originality is highest in this quadrant, and it offers both a research opportunity and knowledge contribution. Although there are elements of

originality in this study, much of it is based on kernel theories, which have been produced in prior research. Hence a claim for totally new solutions would not stand scrutiny.

This leaves the fourth possible knowledge contribution: *Exaptation*. This bottom-right quadrant involves extending known solutions to new problems. The word “Exaptation” was coined by Gould and Vrba (1982) and is helpful to explain development in one area that subsequently becomes useful in another. The classic example of this is evolutionary biology. In the case of human evolution, the growth of the size of the human brain via natural selection had unintended consequences. As the brain enlarged over time, this ultimately led to exaptation of a range of cognate abilities such as art, mathematics and language. Thus, while the development of the size of the skull was initially helpful in providing greater protection to the brain it also allowed different areas of the brain to evolve and become useful in a range of other skills. The idea of exapting theories is explained as follows: *“Original ideas often occur to individuals who have experience in multiple disciplines of thought. Such training allows inter-connections and insights among the fields to result in the expropriation of artefacts in one field to solve problems in another field”* (Gregor & Hevner, 2013 p.347).

The idea of exaptation, or using theories from other areas, has a long history in IS, as many theoretical contributions are drawn from the synthesis of theories from reference disciplines. Therefore, this process is appropriate for the academic community for which this thesis is intended, and is considered, by virtue of its specific role in problem solving, as the most appropriate for this thesis. The implication is that the author has drawn kernel theories from a range of sources that have been exapted as potential solutions to the research question which is how to integrate Green IS into the curriculum. The kernel theories used includes Butler’s (2011) Green IS integrated model, which is backed by institutional and organisational theories. A second exaptation was drawn from Scharmer’s (2009) Theory U. Scharmer did not use Design Science as his research paradigm (his work is situated within action research), and he intended to create a unique process for change that involved personal as well as organisational change.

It is also worth citing Juuti and Lavonen (2006, p.54) who describe design-based research in education as *“long-term projects in single settings and compelling comparisons of innovations and collaborations between researchers and teachers”*. This study meets this definition as it was a six-year project in a single setting, namely the University of Cape Town, and involved innovations developed jointly by researchers and teachers.

4.4 Non-trivial and Interesting

Two important criteria for exaptation research is that the topic needs to be non-trivial as well as interesting, according to Gregor and Hevner (2013). A strong argument for this study being non-trivial is that it addresses a global problem, sustainability, which has been described as one of the major challenges of our times. Anthony Giddens, a leading sociologist, supports this view: *“If unchecked, climate change alone could produce enormous human suffering. So also could the drying up of the energy resources upon which so many of our capacities are built ... in spite of the divisions and power struggles that exist, coping with climate change could be a springboard for creating a more co-operative world”* (Giddens, 2009, pp. 228-229). His sentiments are echoed by pre-eminent climate scientist James Hansen who stressed the urgency of the situation, writing as follows: *“Planet Earth, creation, the world in which civilization developed, the world with climate patterns that we know and stable shorelines, is in imminent peril ... The startling conclusion is that continued exploitation of all fossil fuels on Earth threatens not only the other millions of species on the planet but also the survival of humanity itself – and the timetable is shorter than we thought”* (Hansen, 2011 p. ix).

Yet, despite awareness of climate change, the majority of people are doing very little to alter their behaviours. As Giddens put it, *“For most people there is a gulf between the familiar preoccupations of everyday life and an abstract, even if apocalyptic, future of climate chaos”* (Giddens, 2009, p. 1). This contradiction has been termed the *Giddens Paradox*.

In terms of whether or not this study is interesting, it is acknowledged that this may be a subjective issue. What is of interest to one reader may leave another reader cold. However, for readers who are interested in the future, the environment, the uses of technology as an enabler, the shortage of studies in this domain in Africa - for these readers this study may be of interest. One way of making an issue interesting is to focus on the human element. This enables a response from the reader at a range of levels. At this juncture, it is appropriate to introduce the story of UCT graduate Lewis Pugh, as stories are a way of cutting through the clutter of climate science and to focus on a human response. Professor Pugh recalled swimming in freezing Arctic water and was able to use the power of his mind to increase his body temperature before a swim through a process that UCT’s Professor Tim Noakes coined as “anticipatory thermogenesis”. Pugh recalls: *“The Magdalenefjord swim went off without a hitch. In fact, it was a perfect swim. Spitsbergen is one of the most breathtakingly beautiful places on earth. A massive turquoise glacier feeds into Magdalenefjord with chunks of ice as big as buildings breaking off and landing in the water to float away as icebergs. As I swam past*

them, with my head in the water, I heard a tantalizing sound: a snap-crackle-pop, just like Rice Krispies in milk. It was the sound of tiny air bubbles being released from the ice – air that had been trapped there as much as 3 000 years ago. To swim through this sound, I thought, is to swim in history” (Pugh, 2013 p.61). This is the kind of story that was used to highlight for students the non-trivial and interesting aspect of Green IS.

4.5 Research Design and Data Collection

The case site was the University of Cape Town, which has five faculties, including the Faculty of Commerce. Within the faculty, there are six departments, including IS. It is within this department where the research was conducted, in a third year programme offering project management tuition to students enrolled in the Faculty of Science for a double major with IS.

The DSR approach enabled the researcher to extract data from a broad range of sources. Archival evidence from UCT’s first carbon footprint report, three further carbon footprint reports compiled during the research project, course outlines, assessment rubrics for final presentations, formative and summative evaluations, student reflective essays and mark summaries formed the rich data of this study as shown in Table 6.

Also shown in the table were a range of analytical tools, used for content analysis, which enabled qualitative data to be coded and analysed numerically (Clarke & Braun, 2013). The method of efficiently analysing the data, and generating codes with computer assistance is documented in the literature (Davis & Meyer, 2009). Tools to support the analysis of data included Atlas-ti (Woods, Paulus, Atkins, & Macklin, 2016).

As shown in Table 6, data collection began in 2011 ended in 2017. A final evaluation of the artefact was conducted, shown as the summative evaluations in the final row. This followed a rigorous evaluation process described by Venable et al. (2016), which includes four steps namely goal setting, strategy selection, criteria determination, and evaluation design.

Table 6: Data items accumulated during the longitudinal study.

Source of evidence	Code	Years	Method of analysis
Carbon Footprint Report	CFR12	2012	Atlas-ti
	CFR13	2013	
	CFR14	2014	
Archival Report	CFR07	2007	Word
Course outline	CO11	2011	Word
	CO12	2012	
	CO13	2013	
	CO14	2014	
	CO15	2015	
	CO16	2016	
Assessment rubrics (Final presentation)	AR12	2012	Excel
	AR13	2013	
	AR14	2014	
	AR15	2015	
	AR16	2016	
Formative Evaluations	FE12	2012	Excel, Vula
	FE13	2013	
	FE14	2014	
	FE15	2015	
	FE16	2016	
Reflective essays	RE12	2012	Leximancer
	RE13	2013	
	RE14	2014	
	RE15	2015	
	RE16	2016	
Summative Evaluations	ESE	2017	Atlas-ti
	SE	2017	
	SSE	2017	

4.6 Greenhouse Gas Protocol Methodology

To substantiate a claim for rigour, it is important to note that the subset of data on Carbon Footprinting closely followed the guidelines set down for corporate reporting. This is an internationally-recognised methodology which derives the total footprint by scoping the emissions in a consistent way across the globe. This is the Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard (2013). This document was designed with the following aims in mind: to help organisations prepare a GHG inventory which was a true account of their emissions; to simplify and reduce costs for this process; to provide information to build a strategy to reduce emissions, and to increase consistency and transparency in reporting.

To achieve accurate measurements, the footprint is categorised or scoped down into three areas. The first scope refers to sources of emissions, which are directly owned by the entity. In the case of UCT, this refers to the university vehicle fleet and liquefied petroleum gas (LPG), which is used in the catering kitchens as well as the laboratories. The second scope is described in the protocol as indirect and refers exclusively to electricity purchased by the institution. The third scope is also indirect and relates to sources not owned by the organisation. This covers commuting, official flights, waste, food and water. In terms of the protocol, each element needs to be multiplied by a factor to achieve its “carbon-dioxide equivalent” (CO₂-e) measured in tons.

The factors are internationally established, and for this project, each element was factored by an amount determined by the United Kingdom Department for Environment, Food and Rural Affairs (DEFRA). For example, if the amount of electricity purchased by the university over a calendar year amounts to 70 000 kWh, this needs to be multiplied by an emission factor of 1,054 CO₂/kWh. This would equate to 73 780 tons CO₂-e.

4.7 Ethical Considerations

This study recognises the need of the author to follow the rite of passage from student to scholar with the aid of a range of navigational tools. These include the rules of engagement which set down eight ethical principles which have proved useful in traversing this terrain (Berg, 2016). These are described by Berg (2016) as follows:

- Plagiarism and Honesty
- Risk Assessment
- Informed Consent

- Privacy and Confidentiality
- Data Handling and Reporting
- Mistakes and Negligence
- Working with a Mentor
- Ethics Committee guidelines

Honesty and avoidance of Plagiarism are two linked ethical constructs, as the ubiquity of the internet has led to a spate of plagiarised research documents (Berg, 2016). To combat this situation, the author has applied a duo of tools as safeguards. One is linked to an internal tool, the author's value system, which values honesty and originality. The other is an external tool, Turnitin, which enables a co-occurrence analysis with vast data sources on the Internet and enables reviewers to assess upfront the degree of similarity with past work. Clear citations and references which recognise the contributions of others ensure a mindset which is aware of plagiarised content. In addition, the Plagiarism Declaration at the start of this document indicates that the author understands the meaning of plagiarism and also declares to have not copied the work of others, nor have allowed others to copy her original work.

Risk Assessment is an ethical principle that illustrates that the researchers are concerned with the safety of the participants of her study. In this particular case, there was minimal risk to the participants as they were in a relatively safe space. However, in education research, the roles of researcher and gatekeeper are often conflated, hence particular care needs to be exercised, so as not to diminish the quality of the research (Berg, 2016). During the ethics approval process, the research applied her mind to the potential benefits and risks for study participants. Informing participants of these risks and benefits was therefore carried out prior to conducting the research.

Informed consent is the third ethical principle, and this means that during the design of the study, participants need to be given sufficient information for them to decide on their participation (Berg, 2016). In terms of this study, evaluators and other stakeholders in this study were given the context of the study as well as the opportunity to decline to participate. They were asked to sign consent forms, indicating that they understood the terms of the study.

Privacy and confidentiality are also important considerations. According to Berg, (2016), Privacy implies taking actions to ensure that the data is kept safe while confidentiality is an agreement between the researcher and the participants about the uses of their data (with anonymity

guaranteed to disguise the identity of stakeholders). In this study, generic identifiers were used instead of the names of participants, e.g. ST1 for the student, or EE for the Education Experts.

Data Handling and Reporting is another issue. From an ethical standpoint, there needs to be clarity on the storage and retrieval of data, as well as clear data analysis. Miles, Huberman, and Saldana (2014) recommend computer-assisted qualitative data analysis software, which enables accurate categorisation, labelling, coding and processing, ensuring efficient retrieval from a single location. Creswell (2009) also advises that raw data should be kept for safekeeping. To achieve these two ethical goals, the author used Computer-Assisted Qualitative Data Analysis Software (CAQDAS) for data analysis, in particular, the use of NVivo, Atlas-ti and Leximancer. In addition, the evaluations were housed in the Department of IS for safekeeping.

Mistakes and negligence is another minefield for a doctoral student. According to Berg (2016), these can range from minor errors to potentially dangerous situations. Protection against mistakes and negligence can be via being aware of potential problems and also include collaborators, or “*an additional pair of eyes*” (Berg, 2016, p. 7). In this thesis, the potential for mistakes was reduced via several iterations of review and academic editing.

This leads to the penultimate principle, *Working with a mentor*. Working with an advisor or supervisor has benefits and drawbacks, according to Berg (2016). The answer appears to be having an agreement drawn upfront with expectations and obligations in this relationship. To this end, a Memorandum of Agreement was drawn up between the researcher and supervisor. Updated each year, this listed progress made, annual work plan, supervisor availability, turnaround times for work submitted, and other issues.

Finally, there is the issue of *Ethics Committees*. The intention of such committees is to ensure compliance with an institution’s guidelines and to enable such committees to perform an oversight function as its ethical duty (Berg, 2016). In this case, approval for the study was sought and obtained from the Commerce Faculty Ethics Committee, prior to the collection of data.

4.8 Summary

This chapter explored a range of paradigms to identify which would best suit the research question which examines how to integrate Green IS into the curriculum. The paradigms included positivism, post-positivism, interpretivism, criticalism and DSR. As the question involved developing a new

model as a way of finding a solution to a persistent problem the most appropriate paradigm was deemed to be DSR.

The author then looked at elements at the heart of DSR – ontological issues as well as kernel theories to undergird the study. The kernel theories, which would be at the heart of the innovative model, included Butler's (2001) Green IS framework and Scharmer's (2007) Theory U.

The author also looked at how a knowledge contribution could be positioned in DSR based on Gregor and Hevner's framework (2013). The positionings of the new model as routine design, improvement, or invention were discarded. This left exaptation as the most appropriate solution as it would involve exapting pre-existing theories into a new context.

In addition, rigour was demonstrated through adherence to the Greenhouse Gas Protocol (A Corporate Accounting and Reporting Standard methodology, 2013). Finally, a number of ethical considerations were addressed.

This chapter, then, sets the scene for the next section, where the artefact search will be reported on in terms of DSR requirements and the artefact will be described in detail.

Chapter Five - Design Search and Description of the Artefact

5.1 Introduction

A significant finding in the last chapter was that DSR was the most appropriate paradigm for this research as it sought to design a solution to a real problem, namely the lack of Green IS within the undergraduate curriculum. An important part of working in this paradigm is to produce an artefact that can be assessed on both a practical and theoretical level. Thus, the purpose of the current chapter is to provide a comprehensive description of the artefact at a level of abstraction which will enable it to be assessed as a new contribution to the IS knowledge base. This aim will be achieved via documenting the design search process, which is of an iterative nature. An important facet of this chapter is to elaborate on the development process that led to the discovery of the artefact design. The reason for doing this is to establish credibility as each iteration allowed for the exploration of limitations uncovered at an earlier stage.

The background for the artefact development was set out in the previous chapters, but it is important to note some further contextual details to give the reader a richer understanding. The artefact, which is a model for incorporating Green IS into the curriculum, evolved over a period of six years with a total of 183 third year Computer Science (CS) students. Each cohort of students were enrolled in a first semester course, IT Project Management, over the duration of four months. They were exposed to the real-world problem of campus sustainability and required to form project teams and collaborate with staff on campus. The campus-staff were data holders for a range of sustainability elements, including water, waste, and energy consumption. The CS students, who had elected to do a joint major in IS, were required to complete a real-life project as a practical component of their project management course. Cognisance needs to be taken that these were third-year students, who were used to working more with computers than with people, hence a range of soft skills were required while the challenges of team development needed to be managed by the students with minimal scaffolding. Every year the course evolved to incorporate new trends and become more rigorous and focused on student-centred teaching within the ambit of Problem- and Project-Based Learning (Brundiers & Wiek, 2013). Each year a kernel theory or two were used to inform the theoretical underpinning of the emergent model for integrating Green IS into the curriculum. The organic growth of the artefact will be elucidated during the course of this chapter and the six stages shown in Table 5.

Table 5: Summary of interventions over six years.

Year	1	2	3	4	5	6
Key focus	Conceptualise	Analyse	Footprint	Visualise	Articulate	Condense
No of students	24	30	23	31	39	36
Alignment to charter	Tal loires Declaration	ISCN-GULF	ISCN-GULF	ISCN-GULF	ISCN-GULF	ISCN-GULF
Emergence of Green IS	Green IS - 95	Green IS - 159	Green IS - 261	Green IS - 358	Green IS - 473	Green IS - 592
Technological Changes	Excel	Leximancer	Atlas-ti	Database created	Database upgraded	Database continued
Stakeholders	Intranet site: The Green IS team			Templates created	Templates created	
	Students	Students	Students	Students	Students	Students
	Staff	Vice-Chancellor	Vice-Chancellor	Vice-Chancellor	Vice-Chancellor	Consultants
	Consultants	Consultants	Consultants	Consultants	Staff	staff
Green IS Team Evolution	Forming	Reforming	Storming	Norming	Performing	Performing
Soft Skills	Critical thinking	Critical thinking	Critical thinking	Critical thinking	Critical thinking	Theory U
	Reflective practice	Reflective practice	Reflective practice	Reflective practice	Reflective practice	Critical thinking
	Complexity of Sustainability	Complexity of Sustainability	Complexity of Sustainability	Complexity of Sustainability	Complexity of Sustainability	Complexity of Sustainability
	Communication	Communication	Communication	Communication	Communication	Communication
Key Technical Competencies	Project Management	Project Management	Project Management	Project Management	Project Management	Reflective practice
		Green IT metrics	Carbon footprint	Carbon footprint	Carbon footprint	Project Management
			calculations	calculations	calculations	
Assessment changes	New rubric for assessment					
	Reports		CF Recommendations	Infographics	Concept maps	Trend analysis
	Presentations					
	Ethics letter					
	Business Case					
Outputs and Impacts	2 conference papers	1 conference paper	1 conference paper	1 conference paper	2 Journal articles	Conference paper
		UCT Teaching & Learning Grant	Host for across-campus	Carbon Footprint Report 2013	World Economic Forum	
			Carbon Footprint workshop	Undergraduate Research	Best Practice case study	
			UCT Undergraduate Research	Experience Good	Collaborative Education Award	
			Experience	Practices launch	HELTASA prize	
			Carbon Footprint Report 2012	Revised UCT Cf 2012	Video: How Green is my campus	
					Carbon Footprint Report 2014	

5.2 Design Search Process

In this section, the author illustrates the search for an appropriate design for integrating Green IS into the curriculum as a procedure for finding a solution to the research problem described earlier. This was done within a longitudinal study over the course of six years, with each era marking a significant improvement on an earlier model. The steps taken were to *conceptualise*, *analyse*, *footprint*, *visualise*, *articulate* and *condense*. The first two steps were drawn from the literature (Malhotra et al, 2013) and the last four steps emerged during the reflection process of the previous iteration. Each of these steps is described in turn.

5.2.1 Year 1: Conceptualise

The goal in the first year of the study, 2011, was to *conceptualise* the notion of adding Green IS to the curriculum. This involved various aspects. Firstly, the intention was to draw on the early conceptual literature of Green IS, which was in its formative stages. Secondly, there was a need to conceptualise how to incorporate sustainability within the busy IS curriculum, where the priorities were to create graduates who could seamlessly move into industry. Thirdly, there was a goal of finding theoretical frameworks to undergird the process to ensure rigour. All three goals were interconnected, as illustrated below.

5.2.1.1 Theoretical Background

During the first year of the study Green IS was nascent, and there was a paucity of theoretical frameworks to be considered as one of the kernel theories for the design. At that stage, Nigel Melville from the University of Michigan in the United States had just proposed his 2010 Belief-Action-Outcome framework, arguing that a research agenda on IS for environmental sustainability could be critical for shaping *beliefs* about the environment, enabling and transforming *actions* and improving environmental and economic *outcomes* (Melville, 2010). The model could be critiqued for the fact that the three concepts were difficult to operationalise. In addition, expecting science students who were more familiar with dealing with hard facts, to start from a position of “belief”, could prove inappropriate.

Another emergent Green IS theory was proposed by Australian researchers who proposed a typology by examining the phenomenon from three perspectives: spirit, practice and impact (Ijab et al., 2010). *Spirit* was related to the human values embodied in the structure of an IS (DeSanctis & Poole, 1994). *Practice* was a dimension related to the “*regularized engagement with a particular technology*” (Orlikowski, 2000, p. 407) while *Impact* referred to environmental performance

(Melville, 2010). The typology started with the most impactful Green IS where each dimension was addressed. In other words, the spirit of sustainability was embodied during the design and development phases; it was applied in practice and resulted in measurable environmental impacts. This theory was used to underpin the curriculum in three ways. Firstly, via inscribing Green IS in the spirit of the new curriculum. This was done by changing the course from a largely-theoretical project management course to include the management of project teams within the context of the campus sustainability challenges. Secondly, the practice element was incorporated by rolling out the implementation and regularising the engagement through rewriting the course description to include the new Green IS challenges. Thirdly, the impact was sought via a range of metrics for measuring changes in environmental performance. These included a reduction in energy consumption and reduction in e-waste. However, a weakness of the theory was that it was based on conjecture rather than empirical evidence. Ijab et al. (2010) made an important contribution by proposing the conceptualisation of Green IS, which was one of the implied goals of this research project in Year 1. The authors noted that empirical work could enrich their theoretical notions by appropriation of IS designed with a spirit of greenness (Ijab et al., 2010)

An educational framework provided the kernel theory to inform the design of Iteration One. This was a kernel theory developed by Cockburn for agile software development, based on the three stages of behavioural change, described by the Japanese words “Shu, Ha, and Ri” (Cockburn, 2006). This theory had been used to support the design of the Theory for Coherent Practice, an academic contribution that brought coherency to the delivery of capstone courses for the third-year IS students (Scott, 2012).

The three Japanese words are translated as “Follow, Detach, and (Become) Fluent”. Thus, to guide the design of innovations students needed first to *follow* what had been done previously then *detach* and reflect deeply on what changes they wish to incorporate and ultimately become *fluent*, as if learning a new language with a degree of mastery. This theory was used as a lens to explain the transcendence of the student experience. In the *following* stage interventions were highly controlled including careful guidelines and high-touch tutorial support. During the *detachment* phase interventions continued in a controlled environment but provided the students with an opportunity to reflect deeply on their experience thus far; this was done via a reflective essay, which in itself was a challenge for computer science students. They were expected to identify the mechanics of group dynamics and draw on a palette of tools to understand the processes. A formative assessment at this point helped students to gain insights into the strengths and weaknesses of their project plans.

Then, in the final stage, becoming *fluent*, the interventions enabled students to become autonomous, drawing on their creative resources.

In the first iteration, they were required to perform sustainability experiments across campus, interact with data holders and ultimately present their findings as both project reports and presentations. Scaffolding was minimal at this final stage, and their work was assessed by a team of internal and external examiners for the summative assessment.

Year 1 did not make clear how to fuse together the Green IS and behavioural change theories, but they both provided starting points for the next iteration of the research project.

5.2.1.2. Implementation

Year 1 built on the foundation laid by previous iterations of the IT Project Management course. These included project management theory lectures, workshops, tutorials, a reflective practice element, meetings and a team project. In Year 1 a Green IS lecture was added, presented by the author of this study, which gave students insights into the developing theory of Green IS, sustainability and making a difference. This core element at the start of the semester laid the theoretical lens for refracting the challenges.

In terms of the project management lectures, the theory began with clarifying the basic principles of Project Management (Hartman, 2008). However, there was a danger of producing project managers who were constrained by rigid methodology and unable to think creatively within a challenging context. Therefore, it was decided to incorporate a key element, which would draw on the innate wisdom, gut instincts and creativity of students, and consequently reflective learning practice (Jordi, 2011) was added to the curriculum. This was done midway through the semester, after the students, working in teams, had some experience of the conflicts that inevitably arose in team dynamics.

The students were given access to a range of conceptual tools to help their teams become more manageable. Communication issues were key (Cockburn, 2002), particularly as most of the groups were diverse, with students having different home languages and ways of expressing themselves. Particularly helpful was the understanding imparted that the team could expect to go through stages of forming, storming, norming and performing (Tuckman & Jensen, 1977). They were also given the “Thinking Hats” tool to help them understand the different roles played in a team (De Bono, 1990). This involves the metaphor of different-coloured hats to identify different ways of thinking. The white hat is for facts; the red hat enables students to get in touch with their emotions and feelings.

The black hat enables the opportunity to look at the drawbacks while the yellow hat opens the positive spectrum. Lateral thinking and creativity are signified by the green hat, while program design and monitoring is indicated by the blue hat. Student ST1A noted: *“Most of the time we would end up having debates on which idea would be best. If we would have looked closely into the situation, it would have been apparent that each of us had chosen our ‘hats’ among the six thinking hats’ unknowingly and we were acting on those roles ... At the end we agreed upon that as we were different individuals who would differ in our opinions and this should be acknowledged.”*

Another topic examined reflections through self-assessment within an environment of collaborative learning (Reinicke, Janicki, & Gebauer, 2013). The notion of the leaderful practice lens helped teams to find democratic ways of finding co-created solutions (Raelin, 2011). Readings were given to the students for them to present during class on the soft skills of project management, which included competences such as collaboration and communication. Assessment was done on a continuous basis to gauge coherence (Pellegrino, Chudowsky, & Glaser, 2001). This included both informal and formal formative assessments (such as meetings with tutors, and deliverables submitted according to timelines) with feedback for students to improve deliverables. Rubrics were developed to assess the various phases. At the end of the semester, the groups presented their projects (including a documentation pack comprising the business case, research and implementation processes) and a written examination completed the summative evaluation. A panel of five examiners scored their final presentation. The phases of incorporating the research project into the curriculum are shown in Table 6, including deliverables with specified contents.

Table 6: The five phases of incorporating the research project into the curriculum.

Phase	Deliverable	Contents
1	Identification of the situation of concern	Describe and introduce focus areas
2	Business Case	Macro and Meso levels
3	Interviews and Questionnaires	Make appointments Distribute questionnaires Collect data Process data Data analysis
4	Experiments	Gather information Set up experiments Monitor experiments Process data Analyse finding and implications
5	Formal project presentation and documentation	Present project in group Submit report and powerpoint slides

During Year 1 the students were invited to investigate a range of sustainability issues on campus and to perform experiments for reducing energy. These encompassed the following:

- Monitoring usage and power consumption of PCs and air-conditioning in selected labs in the Faculty of Commerce
- Monitoring usage and power consumption of lab PCs in the Architecture Lab
- Monitoring paper wastage in selected areas in the Faculty of Commerce
- Monitoring usage and power consumption of PCs in Computer Science
- Monitoring power consumption of staff PCs in ICT Services

Students were required to present their work in a professional manner, as can be seen by the exemplar of power saving tips, shown in Figure 9.

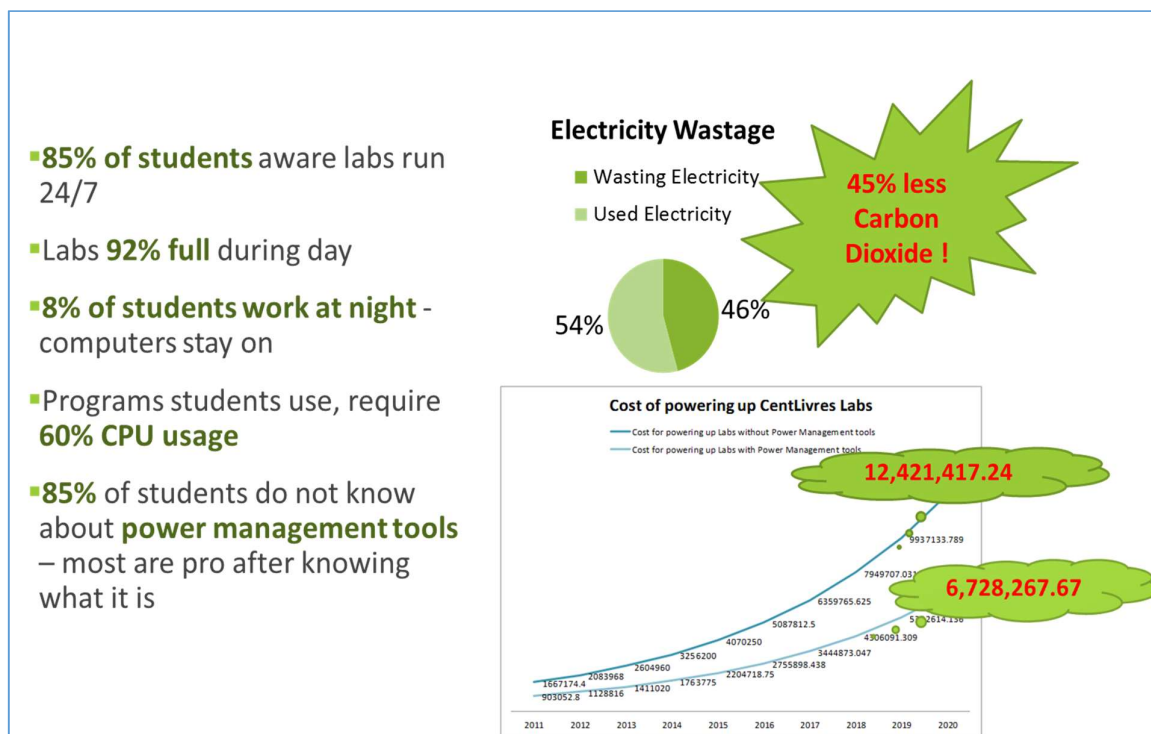


Figure 9: An exemplar of student power-saving tips (Scott, 2011).

An analysis of the reflective essays indicated that each of the groups developed a spirit of “Greenness” as described in the theoretical model (Ijab et al., 2010).

To add a fun aspect to the course, each student was given a t-shirt emblazoned with the slogan “Green IS ... Cool” to wear when they conducted interviews, and a photo session by the university media unit helped to forge their identity as Green IS ambassadors on campus.

5.2.1.3. Evaluation of Year 1 (Formative, Informal)

Turning to the challenges faced in Year 1, it needs to be borne in mind that the course was a key part of the third year curriculum. This means that it was intended to bring concepts from previous courses into the real world via a project (Reinicke et al., 2013). Prior to this, students on the semester-long course had complained that they had not received the depth of experience as their peers, IS students, who were involved in a separate year-long project development capstone course in IS. In particular, they had not experienced the full cycle of system development. Thus the challenge for lecturers was to find a project that contained the complexity of real-world problems (Reinicke et al., 2013). It was also important for value to be added to the wider community with a context-specific project (Avgerou, 2008). A further consideration was to build a topic that could endure over time. Sustainability on campus seemed to be a logical answer to these challenges, but whether or not it would be successful meant taking the risk of putting it to the test.

It became apparent during the year that the chosen theoretical framework (Ijab et al., 2010) was too linear to aid design and that a more systemic model was needed. Fortunately, a new Green IS model appeared in the literature that explored Green IS in a more complex way (Butler, 2011), befitting a complex problem which is unlikely to yield simple solutions. Although the Butler model was based on firms in the IT sector, the author posited that this might be the kernel theory that the team sought to exapt into Higher Education. Year 2 would test this hypothesis.

The range of experiments proved challenging for these undergraduate students. Team 1 explored energy saving options for the university and recommended that computers in the labs automatically power down when not in use. They also proposed that an awareness campaign be instituted at the inception of the academic year to alert students that computers were in sleep mode to save energy. Team 2 also looked at energy saving measures and proposed that free software applications be installed in the computer labs. They identified Joulemeter for recording energy consumption and savings as well as WinOFF to put computers into sleep mode when possible. Team 3 also recommended the use of applications to save energy – Joulemeter and Verdien Edison. They came up with a novel way of saving energy through what they termed *Phased Computing* meaning that students in labs would be directed to the most frequently-used computers, enabling unused computers to remain powered down. Meanwhile, Team 4 conducted interviews and obtained a clear view of issues surrounding campus computing. Finally, Team 5 proposed that the activation of workplace settings could lead to energy savings. They advocated the use of Windows Power Management Settings and developed guidelines in this regard, to educate students and staff to go

Green. While this focus was on the technical side of the case study, they also had an opportunity to explore soft skills during their reflective essays.

The incorporation of the ability to reflect was illustrated in their essays, which were analysed using a tool to extract semantic networks from text. This tool, Leximancer, enabled greater reliability and efficiency in this process (Biroscak, Scott, Lindenberger, & Bryant, 2017). The resultant concepts and themes are illustrated in Figure 11. Circles denote key constructs, including project, communication, thinking hats, time, phase, task and stage, derived from automatic extraction of semantic networks.

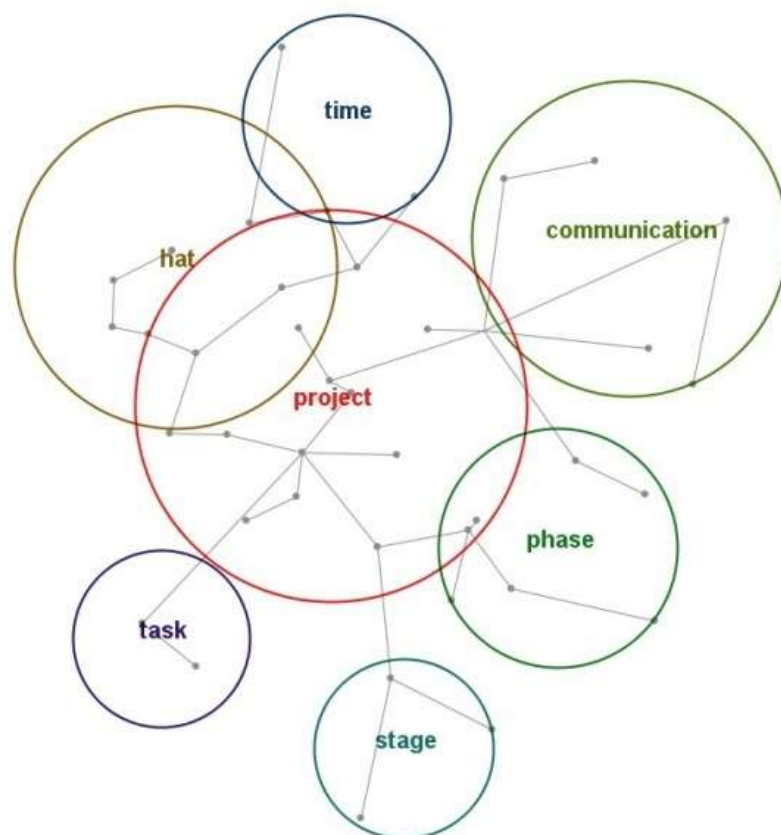


Figure 10: Leximancer map of student reflective essays.

The “Follow-Detach-Fluent” process (Cockburn, 2002) was helpful to guide the students’ progress. The teams agreed what the project from initiation to closure was like a game in which they all focused on a common goal. The first phase, of blindly following, was found to be challenging. However, regular brainstorming sessions where they could reflect on the process enabled them to notice that they were about to transcend. As Student ST1B put it: *“we were approaching the detached phase, as we had to apply various theory concepts in our own style”*.

As seen in the Leximancer map in Figure 10, “communication” features highly as a concept in the reflective essays, second only to “project”. This shows that the course was starting to yield graduate attributes beyond mere technical skills. The concept of “graduate attributes” refers to desirable qualities that university alumni will be required to possess to equip them for future employment (Barrie, 2007). These include intellectual autonomy, problem-solving, critical reflection, teamwork, communication, as well as creative, innovative and lateral thinking. These are attributes which go beyond disciplinary knowledge (Bowden, Hart, King, Trigwell, & Watts, 2000). For the course, these graduate attributes were particularly sought as outcomes.

A formal formative evaluation was the assessment of the quality of the research project via a peer-reviewed international conference. A paper was accepted through a rigorous evaluation process for the European Conference of IS (ECIS). Entitled “Attempts to embed green values in the IS curriculum: A case study in a South African setting” the paper concluded that the incorporation of Green IS into the curriculum opened the door to seeing the campus as a laboratory for conducting experiments related to sustainability, including carbon footprinting, smart water and energy meters, and biodiversity issues (McGibbon & Van Belle, 2013).

5.2.2 Year 2: Analyse

In line with the progression of Green IS scholarly research, which began with conceptualisation and moved onto analysis, the second iteration of model development moved into a phase which the author has named *Analyse*. This meant that the focus of the year was to conduct analysis of environmental data as well as analysis of the literature. One of the shortcomings identified in the first iteration was the shortage of available theoretical frameworks for Green IS and Year 2 was intended to prioritise analysing the available literature with a view to finding a theory, which would guide the design science research project. In addition, there was a focus on the technology side of sustainability known as Green IT.

5.2.2.1. Theoretical Background

In Year 2 it was decided to test Butler's (2011) theoretical framework as a possible kernel theory for the artefact design. A simplified version of the model is shown in Figure 11 and indicates a process that began with three influences (regulative, normative and cultural-cognitive) to Green IS-enabled activities and ends with organisational outcomes, such as sustainability reports.

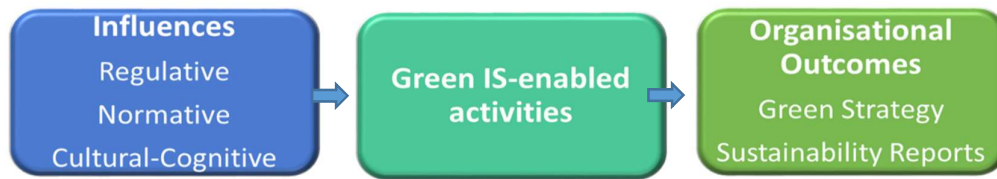


Figure 11: An integrative model of Green IS (based on Butler, 2011).

As the Shu-Ha-Ri model mooted by Cockburn (2006) had worked reasonably well in Year 1, there was no need to refine it at this stage. The year was a significant one for UCT, as the Vice-Chancellor signed into the record books his commitment to sustainability. On 12 May 2012, Dr Max Price signed the charter developed by the International Sustainable Campus Network – Global University Leadership Forum (ISCN-GULF), committing the university to incorporate sustainability into all its affairs including the curriculum. This aligned with the mission of ISCN-GULF, which was to create a global platform to support Higher Education through encouraging best practice for sustainable campus operations as well as the integration of research and teaching.

5.2.2.2. Implementation

Since the Green IS project had been successfully incorporated into the curriculum the previous year, there were minimal changes in terms of the formative and summative assessments. However, the focus of the year changed this time to Green IT. At that stage both Green IS and Green IT were linked in academia, and the author gave lectures on both topics to the class. Butler's (2011) model was presented along with several other models.

An important area for growth in the course was the development of stakeholders. The ICT team played a key role, as did the university's sustainability consultant, Sandra Rippon. She had been the motivator behind UCT signing the International Sustainable Campus Network charter and was tasked with compiling its first reports. The responsibility for collecting, storing, reporting and continuous monitoring of the UCT carbon footprint was given to the IS Department in the Faculty of Commerce. This was significant, as the initial carbon footprint for UCT, for 2007, had been housed in the Energy Research Centre in the Faculty of Engineering and the Built Environment.

5.2.2.3. Evaluation of Year 2 (Formative, informal and formal)

The focus of the year was on Green IT as opposed to the broader notion of Green IS. It was noted that Green IT, which was intended to reduce the footprint of ICTs such as improving the energy efficiency of hardware and reducing e-Waste, could be considered the first wave (Curry & Donnellan, 2012). The second wave involved shifting the focus to the innovative use of IT and IS in processes to deliver positive sustainability benefits beyond the direct footprint of IT (Curry & Donnellan, 2012). It was decided to position the future research projects within the second wave, the growing body of Green IS. The reason for positioning it included an understanding that IS brought to bear not only technology but also human beings and the phenomena that emerged when the two interacted. This change was reflected in the course outline for the following year, where it was stated that the students would engage with the application and implementation of Project Management tools and techniques using a team-based IS project in a real-life setting and that the year's project would focus on Green IS.

During the formal course evaluation, there was a 50% response rate. This was considered a low response, and a decision was taken to allocate a mark for students to evaluate the course, in a bid to incentivize them to complete the evaluation. The rating for the course relative to other courses was measured with only 34% of the class considering it to be excellent or good. Positive aspects of the course included *“getting to work on a real-world project and make a contribution to UCT”* (ST2A) as well as the benefits of soft skills such as working in a team, presentation, project management and self-learning. As one student evaluator said: *“I love the fact that we got to tackle a real problem and our suggestions were promised to be solutions”* (ST2B).

5.2.3. Year 3: Footprint

Since Butler's Green IS theory had proven successful in the previous iteration, Year 3 continued to use this as a kernel theory to underpin the developing DSR model. The sustainability focus became more dominant as the theme for the year involved measuring and reporting on the campus carbon footprint to meet the reporting requirements for the international charter.

5.2.3.1. Theoretical Background

The model for Green IS continued to be Butler's (2011) theory which he had since developed and refined in a book chapter (Butler, 2012). His revised version included the primacy of stakeholders in the model. In effect, it was the issue of stakeholder relations that took centre stage for the Green IS course which needed to develop strategic partnerships not only with the executive for properties

and services who oversaw the carbon footprint process but also with external consultants who would provide, via auditing, the carbon footprint at UCT.

5.2.3.2. Implementation

A teaching case was developed for the class, elaborating the first footprint for UCT and challenging the students to assist the university to reach its mandate of producing an accurate GHG emission report within one semester as opposed to the two-year long process when the first campus footprint was produced (Letete, Mungwe, Guma, & Marquard, 2011). There were no key changes within the theory, teaching and learning aspects of the course, but some important outputs and impacts were established, as evidenced in the evaluation process that follows.

5.2.3.3. Evaluation of Year 3 (Formative, formal and informal)

In 2013, UCT published its first Carbon Footprint Report aligned with the ISCN-GULF and Corporate Standards protocol. The undergraduate research aspect of the course attracted the attention of the university top management and the Green IS task team was invited to join a campus-wide initiative to identify and publicise best teaching practices linked to undergraduate research.

An empirical analysis of student reflective essays showed that network cultivation was the dominant mechanism used in the process to collate the carbon footprint. This could not be explained by Butler's three influences (regulative, normative and cultural-cognitive) hence the argument was proposed for a fourth influencer. In the theoretical elaboration section of the paper, it was mooted that an informal network of staff and postgraduate students were responsible for a *collaborative* pressure. Support for this came from Campbell (2005) who argued for four types of embeddedness – regulative, normative, cultural-cognitive as well as *network* pressures. This *collaborative-network* pressure was therefore mooted as an enhancement to Butler's (2011) model and shown in Figure 12.

As can be seen from the model another change to the organisational outcomes was included at this stage with the production of the Carbon Footprint Report. Edited by Rippon (2013) it was noted on the report cover that data gathering and calculations had been carried out by students.



Figure 12: Changes to Butler's model to include Collaborative influence and Carbon Footprint Report.

The ongoing research was presented at the European Conference on Information Monitoring and Evaluation (ECIME) at the University of Gdansk in Poland. The title was: *Integrating Green IS into the curriculum using a carbon footprinting case* (McGibbon & Van Belle, 2013). This conference paper represented a formative evaluation of the evolving model as it was peer-reviewed by international experts. The paper included the teaching case presented to students with these opening lines: *"Situated on the spectacular slopes of Devil's Peak of the iconic Table Mountain range, UCT is a symbol of hope for the future, holding the dreams of the next generation of scientists, artists, managers, professionals and other leaders of tomorrow. It faces a serious challenge: it is committed to reporting on its Carbon Footprint, yet it does not have the capacity to do this. Can you help the Vice-Chancellor to deliver on his promises? Amongst the findings of the paper, were that "a more robust method of collating the data, using Green IS (integrated IS to enable environmental sustainability objectives) could go a long way to enable the campus to meet its mission"* (McGibbon & Van Belle, 2013). In terms of the formal course evaluation, there was a 78% response rate. The value of a real-world experience was stressed by evaluators, especially the combination of technical and soft skills. In terms of lecturer feedback, the researcher's knowledge of Green IS was seen as excellent or good by 72% of the class. Negative comments focused on poor communication and the need for visualisation – *"mis-communication and clarity on some aspects wasn't 100%"* (ST3A) and *"Creating a mock-up of how data can be collected and analysed could provide more relevance to ComSci"* (ST3B).

5.2.4. Year 4: Visualise

In the previous iteration, communication had been identified as a key area that led to the realisation that students needed to express themselves not only via written skills and verbal presentation skills but also visually. Hence, there was room for growth in the area of visualisation. This was at a time when infographics were becoming mainstream, and the author proposed that students view some of

the powerful visual messages around climate change, to tell the story beyond the numbers. Carbon footprinting can be perceived as boring if it is presented merely as lists of tables or percentages. The need to visually represent the data became apparent as a means of enhancing understanding by audiences.

5.2.4.1. Theoretical Background

The researcher used an adaptation of Butler's (2011) framework to undergird the artefact development as depicted in Figure 13. Changes to the model included the financial influence, as well as a database for Carbon Footprinting as a key element within the Green IS-enabled activities frame.

The focus of the year was on "visualisation", and as the need for greater clarity had been identified as a shortfall in the previous iteration. In addition, the author explored some aspects of visual elicitation in the literature, this was exapted into the IS curriculum. According to Smiciklas (2012), visual communication such as infographic illustration is helpful when there is a danger of information overload. Transmitting knowledge and ideas visually helps audiences to understand complex data. This is supported by a trend in data gathering research to use visuals as a means of obtaining data (Crilly, Blackwell, & Clarkson, 2006). Furthermore, Bagnoli (2009) argues that graphics can enable students to express their own interpretations through creating their own associations and meanings.

UCT has been grappling with the issue of how to visualize climate change for some time. In 2011 it held a Hot Water Festival uniting scientists and artists exploring how best to communicate these issues and whether arts curricula need to be changed to incorporate notions of climate change.

It also needs to be noted that the region has a long history of visual representation. If one considers the artwork created on the walls of caves in Southern Africa, which date back hundreds of years. For example, Wilhelm Bleek, a German linguist who attempted to learn the /Xam San language, made a statement to parliament that San rock art, depicting intricate dances and finely shaded antelope represented "a truly artistic expression of the ideas that most deeply moved the Bushman mind, and filled it with religious feelings" (Bleek, 1875, p. 13). This deep linkage to Southern African rock art clearly had an influence on the idea for the author of not only representing environmental data in terms of numbers and words, but also in visual images.

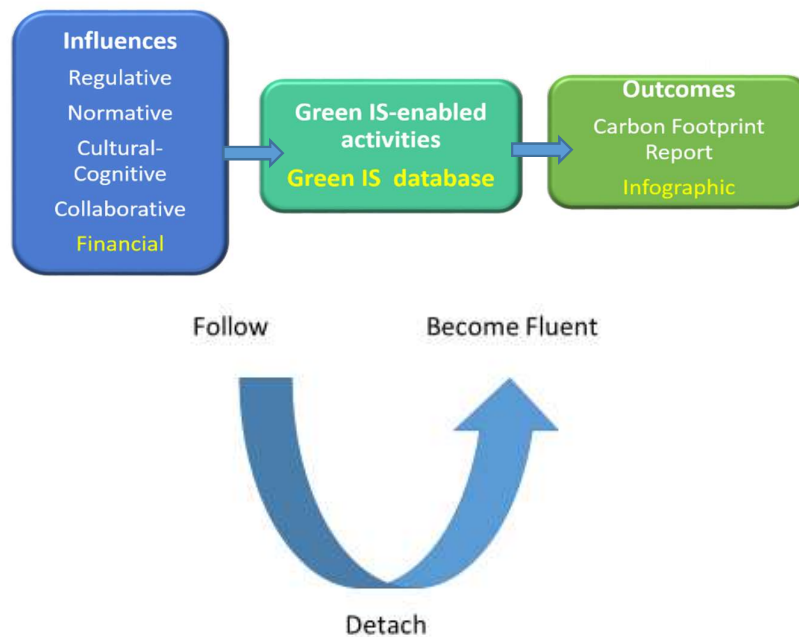


Figure 13: Development of Green IS model in conjunction with Cockburn's theory.

In addition, it was observed from the data that the process of following, detaching and becoming fluent was occurring simultaneously with the Green IS implementation. The data suggested that this could be expressed as reaching a turning point and changing direction. This had resonance with other behavioural change models such as Theory U (Scharmer, 2009).

5.2.4.2. Implementation

Changes to the course assessment were introduced as can be seen in Table 7. Specific changes were the introduction of the business case (which counted for 4% of the total mark), with a stronger weighting given to the role of the reflective essay (3%) and reflective presentation (2%).

At this stage, the examination counted for 60% of the year mark whereas the practical learning experiences only amounted to 39%. In order to encourage students to complete the course evaluation, this formative evaluation was also given a nominal value (1%).

Table 7: Gradebook for Year 4.

Activity	Weighting
Business Case	4%
Tutorials	5%
Reflective Presentation	2%
Reflective Essay	3%
Project Presentation	10%
Final Project Report	15%
Examination	60%
Course Evaluation	1%

5.2.4.3. Evaluation of Year 4 (Formative, Informal and Formal)

In keeping with the theme of this iteration, the Project Presentation Evaluation rubric included an extra element: students had to present their findings visually. Assessment included the criteria that the poster should be easy to understand, readable, interesting, and devoid of grammatical or spelling errors. Teams scored 10% of the total assessment for their infographic with a challenge to come up with creative and insightful graphics, including what was termed “the WOW factor”. Students rose to the challenge and responded with creativity and insight, as shown in Appendix D.

Returning to the artefact development search, it will be recalled that the Green IS-enabled activities centred on an IT element, namely a database. This was built by the author as a way of connecting a range of stakeholders, including students, lecturers, researchers, consultants and administrative staff. The university’s intranet site, Vula, was used as the repository for annual environmental metrics for the Carbon Footprint. These were categorised according to the scope laid out in the Corporate Reporting guidelines established globally, adding rigour to the process.

The introductory page read: *“This is an exciting space where UCT’s Carbon Footprint Champions – data holders, students and staff as well as other stakeholders can interact as part of the process of producing campus carbon footprint reports. The site contains all the data used for reporting as well as the final reports. We also keep records of all the resources that are used in the process as well as all the work produced by students as part of their projects”*.

A benefit of setting up this database, and links to stakeholders, meant that a Green Information System had been created to collate all data in one portal. Not only did this enable transparency but also made it easier for students or others to access relevant data, by year or by category.

During the informal reflective evaluation by the team of Green IS academics they identified that they had reached the “norming” phase of development. Earlier power struggles had been resolved, and the team members were able to appreciate their various strengths.

The formal formative evaluation yielded some useful data. It will be recalled that students who completed the course evaluation were awarded 1%, as an incentive for them to reflect on the course. This also enabled a richness of data, as they were encouraged to comment on positive and negative aspects of the course. There was an 84% response rate to the perceptions of the course relative to other courses. A total of 44% of the class rated the programme as either “excellent” or “good”.

During the course evaluation, 65% of students rated the usefulness of the project as a learning experience as either “excellent” or “good”. Positive aspects of the course included the teamwork described as: *“really well organised”*. Referring to soft skills development, Student 4A noted personal growth in the area of *“enhanced leadership capabilities, and improved my decision making”*. The dominant theme of the most positive aspects of the course was “teamwork” as shown by Student 4A: *“Looking back on it, carrying out this carbon footprint project was hard work, but because of the effort and time spend doing it, I feel like we produced an impressive end product. I found that I have an aptitude for teamwork ... being in a leader’s position was a valuable experience because I learned that you need to be accommodating and flexible, while still managing to keep the vision and goals of the project alive...”*

Negatives included a criticism of the sustainability aspects. Student 4B complained: *“The course is labelled Project Management, but we spent half our time learning about carbon footprints and Green IS.”* Student 4C also highlighted challenges with data collection: *“Could of (sic) done with more time for final project/report. Ensure data holders are on board and emphasise the need to get data to students faster...”*

Recommendations in the UCT carbon footprint report included a suggestion for providing data holders with a template for each component of the footprint. Upon this recommendation, this

aspect was included in the following year as a deliverable from each team. The call for a secure and Green Information Systems platform was not acceded to by management, so the database developed by the researcher on Vula remained the primary Green Information System. The Follow-Detach-Fluent model was also questioned for its ability to be operationalised, and a literature search was conducted in the change management space to find a new kernel theory. This turned out to be Theory U (Scharmer, 2009).

5.2.5. Year 5: Articulate

Recommendations in the UCT carbon footprint report included a suggestion for providing data holders with a template for each component of the footprint. Based on this recommendation this aspect was included in Year 5 as a deliverable from each team. A recommendation for a secure and accessible platform for the collection of the carbon footprint data was not taken up by the university management, hence the database developed by the researcher on Vula was carried forward.

In essence, the focus for this iteration was to create an articulate view of the model, which was evolving according to DSR guidelines, namely seeking to enhance the artefact based on data gathered in the previous iteration. In addition, there was a need for students to reflect not only on words and pictures to express their findings but also how to weave these together into a coherent and articulate discourse. Hence the theme for this iteration was described as “Articulate”. The catalyst for this was to inspire and challenge them with the story of Professor Lewis Pugh, polar adventurer and global advocate.

5.2.5.1. Theoretical Background

It will be recalled that the Follow-Detach-Fluent model was found to be deficient in the previous iteration for reasons of difficulty in operationalising. The “follow” aspect was considered vague, as it was unclear what should be followed and why. Likewise, the “detach” construct was also too vague, as it did not clarify the elements of reflection that had become embedded in the student experience. Finally, the “fluent” construct, while appropriate for learning computer languages, was considered too opaque within the current context.

5.2.5.2. Implementation

Shortly before UCT graduate (and current law professor), Lewis Pugh, achieved his goal of swimming at the North Pole in melting sea ice, to raise awareness about climate change, he was given a motivational talk. His friend David Becker inspired him with the idea of three “anchors” as a way of helping him not to be intimidated by the size of the task ahead.

'The first one is this: it is crushingly obvious that the idea of swimming a kilometre is absolutely impossible. But I know that you can swim 100m because I saw you do that yesterday. Don't think of a one-kilometre swim,' he said. It's too far. Just think about the 100m you are doing, no more. We had 10 national flags with us, representing the nations that had played a role in this swim. 'Each 100m you swim, you'll be swimming for them.' It was a fantastic idea. Not only because it recognised the enormous contribution of all the people behind the expedition, but also because of its symbolism – wherever you are on this earth you will be impacted by what happens in the Arctic.

There were two more aspects to David's plan. The first involved going back to the beginning of my life and walking through everything that had brought me to where I was now – moments of adversity as well as moments of triumph ... For the final anchor, David took me to the end of my life and asked me to look back. What was the legacy I wanted to leave? Was I going to be able to look back and say that, when the time came, I stood up? 'In the last two years 23% of the sea ice cover has melted away. You shouldn't be able to swim across the North Pole; it should be frozen over,' he said. 'But it isn't, and so you will swim across it, Lewis. I want you to shake the lapels of the world's leaders so they appreciate that climate change is the most pressing issue they must address' (Pugh, 2013, pp. 179-181).

This story of Lewis Pugh, 'the human polar bear' was used to inspire and motivate the class during the fourth iteration of the programme. Rather than being overwhelmed by the enormity of climate change, the students were urged to follow the example of Lewis Pugh, and make a difference, no matter how small.

They were challenged with the question: "If your grandchildren ask you: 'what did you do?' how will you answer them?" This inter-generational thinking was essential if the students were to make a difference. Beyond the number and the predictions, it was important to humanise the issue of sustainability. Elsewhere in the world, storytelling has been identified as a means of coping with the unpredictable future posed by climate change (Sakakibara, 2008). Closer to home, a South African artist/scientist has been grappling with ways of communicating the issue of climate change in ways that will find relevance with local people (Claassens, 2016) and has critiqued the use of polar bears imagery to tell the story.

However, the notion of the polar bear as an icon for climate change has had a resonance on the UCT campus. During the “Hot water art and climate change” exhibition at Hiddingh in 2011, artist Brendhan Dickerson created a performance installation of a giant moving polar bear fire sculpture.

“For me the tragedy of polar bears becoming exhausted and drowning, while swimming around looking for a chunk of ice to climb onto, has become iconic of the climate change crisis ... A larger than life-size, fully articulated swimming polar bear fire-sculpture, weaving back and forth along a cable, 6m overhead. Paddling desperately, looking for a chunk of ice - burning up, burning out, fading out and dying. The kinetic polar bear fire-sculpture is operated by two hooded puppeteers (reminiscent in their protective leather hoods, of medieval executioners). On the ground, like a Greek chorus, just outside the puppeteer’s field of movement, an array of singing kettles are set to boil on gas rings. As the bear burns down, the kettles begin to emit an ever-increasing cacophonous whistling - piercing and irritating - intended to evoke a sense of alarm, of impending catastrophe” (Dickerson, 2011 p.1).

This makes pertinent the idea that for many scientists, the issue of climate change has become difficult to articulate. In addition, for many people, the issue is too technical or too long-term (Giddens, 2009). Hence there is a need to find ways of storytelling with the focus on human responses. To this end, a video crew was brought into the final class to film the changes that students had undergone during the course. The weightings are reflected in Table 8.

Table 8: Gradebook for Year 5.

Deliverable/Activity	Weighting
Del 1 - Macro Model & Context Diagram	2%
Del 2 - Business Case	4%
Infographic, Final Report and External Assessment	15%
Tutorials	6%
Project Presentation	10%
Reflective Essay	8%
Reflective Presentation	8%
Microsoft Project Plan	6%
Examination	40%
Course Evaluation	1%

Major changes were made in how the work of students was assessed, as shown in Table 8. For example, the examination was allocated only 40% of the final mark, in line with the realisation that project management was a very practical course, and theoretical components tested in the exam were deemed to carry less weight than the practical elements. In addition, there was greater clarity on how various elements were weighted. So, the first deliverable, developing a macro model and context diagram counted for 2%, and the business case was worth 4%. In addition, marks were allocated for participation in tutorials. Another innovation was an allocation of 6% for a Microsoft Gantt chart. The course evaluation remained at 1% as this had been shown to encourage students to complete their comments on the course, with rich data as shown below.

5.2.5.3. Evaluation of Year 5 (Formative, Formal and Informal)

Before the course, 37% of the class remarked that their understanding of sustainability issues was “none or slight”. After the course, 53% of the class reported that their understanding of these issues was “substantial”. The formal evaluation had a 77% response rate, and the rating of the course relative to other programmes was as follows showed that 60% of the class considered the course to be excellent or good. Positive comments from the course evaluation linked to the real-world aspect of the course.

Student 5A said: *“I learnt a lot of things that I can actually apply in the real world. It was more of practical work not theory which is good.”* Teamwork also got the thumbs up from Student 5B: *“Really enjoyed working in a group for this project, we worked well together and the actual project itself was super interesting 😊 loved doing it and the presentation was super exciting”*. Student 5C specifically noted the value of *“soft skills needed in teamwork”* and *“reflection stuff”*. Student 5D added: *“helped me to learn about environmental sustainability, especially as an international student ... It helped me to gain a perspective from a different area of the world”*. This was mirrored by Student 5E: *“The UCT community as a whole contributes a lot to global warming. It is up to us to make up for what we contribute to global warming and do what we can to decrease our carbon emissions ... I realise now that, we all have to do our part, if we’re to survive longer on this planet”*.

Negatives included criticism of the sustainability aspect. Student 5F said: *“I found myself not very interested in the project scope and while I learnt a lot and don’t regret it I think I would have been a lot more excited and motivated to work on something more relevant to my field than UCT’s carbon footprint”*.

This was countered by Student 5G: *"I've become more aware of the different environmental issues on our campus. Our campus can play a huge role in either polluting the community, or serving as an example of how to properly behave in an eco-friendly manner"*.

An evaluation of the quality of the intervention was provided in a letter of recommendation by the Dean for an entry towards "Excellent Team Teaching", a national competition run among universities by the Higher Education Learning and Teaching Association of Southern Africa, HELTASA. He noted that the project of incorporating Carbon Footprinting into the curriculum ticked a number of boxes relating to student engagement.

He wrote: *"All university leaders speak regularly about the value of integrating taught content, reflective pedagogy, meaningfulness to student experience, social responsiveness and translation of research into practice. It is rare, however, for all of this rhetoric to truly characterise any particular actual element of a curriculum. The carbon footprint project is one such unusual instance. The project delivers on its primary aim in the context of the IS and Computer Science majors by teaching students how to combine the practical and theoretical knowledge they have learned over the course of their degrees into the execution of a project. This is the essential skill that an IS must carry into the workplace after graduation in order to function as an effective professional. The course is, therefore, a capstone course in the proper sense of the word"* (Ross, 2015).

The entry won the award for excellence in team teaching, and this was reported in UCT media release as follows:

"The team received an award for Excellent Team Teaching. The selection committee highlighted the innovative nature of the intervention to integrate carbon footprinting into the IS curriculum with students from the Science Faculty who are studying project management. The trio were recognised for uniting to form the most excellent teaching team in South Africa in 2015. Their project, which inspires students to make a difference by collating UCT's carbon footprint, is in its fifth year. It was noted that the portfolio provides evidence of local and international impact. In addition, it was observed that the project not only provides students with an opportunity to increase awareness of climate change but also enhances graduate attributes such as intellectual autonomy, problem-solving, critical reflection and innovative thinking" (University of Cape Town, 2015).

5.2.6. Year 6: Consolidate

A gap in the previous year was identified in that one of the key graduate attributes, critical thinking, had not been a core element of the course and this gap needed to be filled. In addition, the recommendations made by students in previous years for making campus operations more environmentally friendly had not been implemented, and this shortfall was addressed in the sixth iteration.

Since carbon footprinting had been successfully incorporated into the project management programme, it was decided that value could also be added by looking at the trends that had started to emerge as a way of gaining deeper understanding of Green IS, including the opportunity to critically evaluate its contribution. During the sixth year a decision was made to change the curriculum for the year in that students would not be required to measure the carbon footprint from the previous year, but instead to report on trends of the footprint at UCT from 2012 to 2014, make recommendations on possible solutions and provide information to incentivise going green. Hence this was to be a year of consolidation.

5.2.6.1. Theoretical Background

As will be recalled from Chapter 3, the search for kernel theories to undergird the new model led to the literature of organisational change management. To summarise, the field has been critiqued for its range of somewhat contradictory models, with untested hypotheses and lack of empirical evidence (By, Armenakis, & Burnes, 2015). More recently, solid empirical work has come to the fore, building on Lewin's three-step model of change, Rogers' diffusion theory, Argyris and Schon's organisational learning and Schein's organisational culture (Batras, Duff, & Smith, 2016).

Chapter 3 identified a gap in the sustainability education literature, enabling the researcher to examine change theories related to unstructured problems. Hence the search led to the change management model called Theory U. Scharmer (2009) posited that there were two types of learning. The first was about learning from the past (Kolb, 1984) which follows the sequence: "action-observation-reflection-design-action".

There is another kind of learning which he called "the emerging future" (Scharmer, 2009, p. 560) as shown in Figure 14. Based on interviews with 150 practitioners and numerous reflection workshops, action research studies found that learning from the future was a creative process that allowed participants to *"let go of patterns of the past and connect with what is emerging. We call this the U-*

process (named for the shape of the diagram that outlines it), and it happens in many different settings, in the creative arts as well as in organisations” (Scharmer, & Kaeufer, 2010, p. 23).

This model also maps neatly onto the U-shape explored in the previous year, as both models strongly indicate movement from one direction to the point of reflection – “detach” in the Cockburn (2006) model and “presencing” in the Scharmer (2009) model, and then changing direction. These key elements of U-theory (the U shape and presencing construct) were thus incorporated into DSR artefact created in this study, shown later in this chapter.

Scharmer (2009) describes the left-hand side of the “U” as a process where a group co-initiates a change intervention (*Co-initiation*). This starts with *Downloading*, which is a focus on listening to what happened in the past (Scharmer & Kaeufer, 2013). Next, there is *Suspending*, which implies stopping old habitual patterns, followed by *Redirecting* (which means redirecting attention from the exterior to the interior) and *Letting Go* suggests an acceptance (Scharmer, 2009).

Presencing is a term coined by Scharmer based on group cognition to bring into presence the highest future possibility (Scharmer, 2009). On the right-hand side of the “U” there is a new threshold to cross, and this is called *Letting Come*, which is the space for envisioning the future. This is followed by *Crystallizing* (clearly anticipating the future scenario), *Prototyping* (explore the future by doing) and ultimately *Performing* (embedding the future in practices and infrastructures) (Scharmer, 2009).

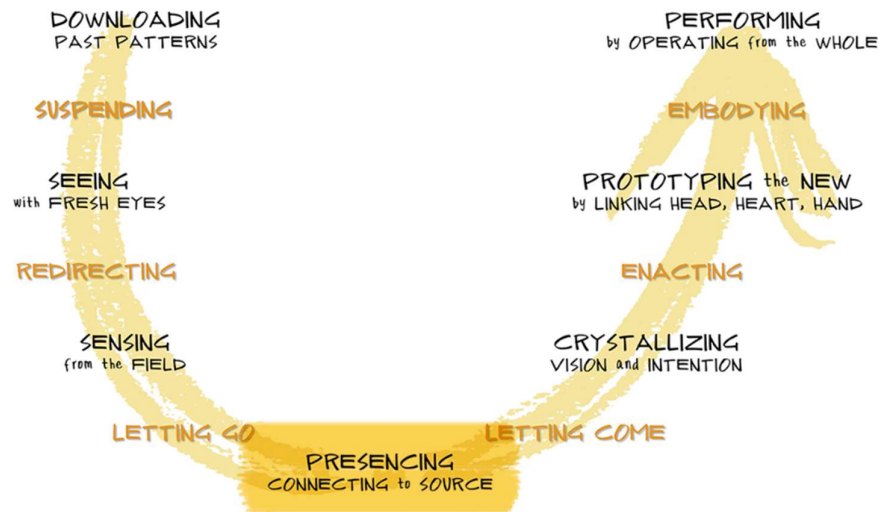


Figure 14: Theory U showing the construct of presencing at the turning point (Scharmer, 2017).

There are many versions of U practice, for example, the one described by Scharmer and Kaeufer (2010) has a sequence of just three elements: *Suspension*, *Redirection* and *Letting Go*. This aligns with Buddhist meditation practice, where one learns to “*settle the mind*” (Tan, 2016. P. 85). This process is claimed to enable a relationship to develop between “*relaxed attention and creativity*” (Tan, 2016, p. 31). The practice of “relaxed attention” has a growing understanding in the West, as this comment from Apple Computers co-founder Steve Jobs shows: “*If you just sit and observe, you will see how restless your mind is. If you try to calm it, it only makes it worse, but over time it does calm, and when it does, there’s room to hear more subtle things – that’s when your intuition starts to blossom and you start to see things more clearly and be in the present more. Your mind just slows down, and you see a tremendous expanse in the moment*” (in Tan, 2016, p.32). In his book, *Joy on Demand*, Tan tells the story of a meditation master who held the following conviction: “*If meditation (which he calls ‘the internal science and technology of the East’) were to successfully mate and cross-fertilize with the science and technology of the West, it will change the world dramatically, for the better*” (Tan, 2016, p.36).

Another version of the “U” has five movements. It starts with *Co-initiating* (Listen to others and yourself), moves on to *Co-sensing* (Go to the place of most potential and listen with both open mind and open heart wide open), then *Co-presencing* (“*Retreat and reflect, allow the inner knowing to emerge*”), *Co-creating* (Explore the future by doing) and ultimately *Co-evolving* (Grow from the emerging whole) (Scharmer, 2009, p. 378). Yet another has seven elements, starting with

Suspending and ending with Institutionalizing (Senge, Scharmer, Jaworski, & Flowers, 2004). Hence it may be surmised that there are many variations of U theory, which all have in common a movement downwards to the point of presencing and then moving in a completely different direction. As an introduction to the concept, therefore, it was decided to draw on the essence of the kernel theory, the meta-kernel as it were.

5.2.6.2. Implementation

The project brief for the year indicated a consolidated approach based on the previous iterations of the programme, which had observed three carbon footprints for the campus (Rippon, 2013; Rippon, 2014; Rippon, 2015). Each year, the data collection process had been refined in order to increase the rigour of the process, enabling more comprehensive and reliable reports. However, a challenge had been identified in terms of the failure of implementation of the recommendations and this iteration aimed to consolidate the previous reports and engage with this particular challenge.

The course was constructed in such a way as to include tutor assessment as shown in the gradebook in Table 9. This would enable greater support for students. Changes in this iteration included a 2% score allocated by the external consultant – this added a layer of rigour via external moderation. Tutor assessments (4%) were also added, as a way of giving formative feedback to the students, as the lack of a class test had been identified in the past iteration as a gap in terms of formative assessment. In addition, the Microsoft Project Plan (6%) was removed from the list of deliverables, as students were encouraged to apply creative thinking to this process. The course evaluation remained at 1% of the final mark, leading to nearly 90% of the students completing this section.

As can be seen from Table 9, students were given greater clarity on exactly how their final mark would be calculated. For example, each of the four tutorials was labelled. These four tutorials were described as design thinking, business case and project definition, project scheduling, and risk management. The teams were again divided up into groups according to the scope of previous footprints and were able to extract electricity, water, gas and other environmental data from the intranet database.

Table 9: Gradebook for Year 6.

Deliverables	Weighting
Del 1 - Macro Model & Context Diagram	2%
Del 2 - Business Case	4%
Infographic	4%
PM Practice	4%
Tutor Assessment 1	
Tutor Assessment 2	
Tutor Assessment 3	
Tutor Assessment 4	
Project Presentation	10%
Reflective Essay	7%
Reflective Presentation	8%
External consultant's assessment	2%
Tutorials	8%
Tutorial 1 - Design Thinking	
Tutorial 2 - Business Case & Project Definition	
Tutorial 3 - Project Scheduling	
Tutorial 4 - Risk Management	
Final Project Report	10%
Examination	40%
Course Evaluation	1%

5.2.6.3. Evaluation of Year 6 (Formative, Formal)

The formal course evaluation was completed by 89% of the class, and the ratings, relative to other courses gained scores of “excellent” and “good” by 63% of the class (see Figure 15 for the complete range). Positive aspects of the course included soft skills such as teamwork and the practical aspects of the course, as described by Student 6A: *“Project management is best tested through an actual project instead of a test. Thus I am glad there was a project as opposed to the usual Test 1 and Test 2.”* Another comment from Student 6B: *“Great that IS students are broadening their understanding and being exposed to issues like sustainability”*. On the same theme was this insight from Student 6C: *“I have always been a person who has been conscious of the environmental issues surrounding*

us, with active participation in Green Societies from High School and carried on to Varsity. But I think right now, with regards to GCI itself I feel as if they do not educate the UCT community enough on the issues that have been presented in the various groups in their reports. People know about recycling and the bin system, but no one knows about the emissions produced by the vehicles, or the amount of e-waste we produce. So the project has actually educated me in other areas that I have never been taught about in high school or varsity". Another student remarked on a personal change: "I have minimized my power consumption" (ST6D).

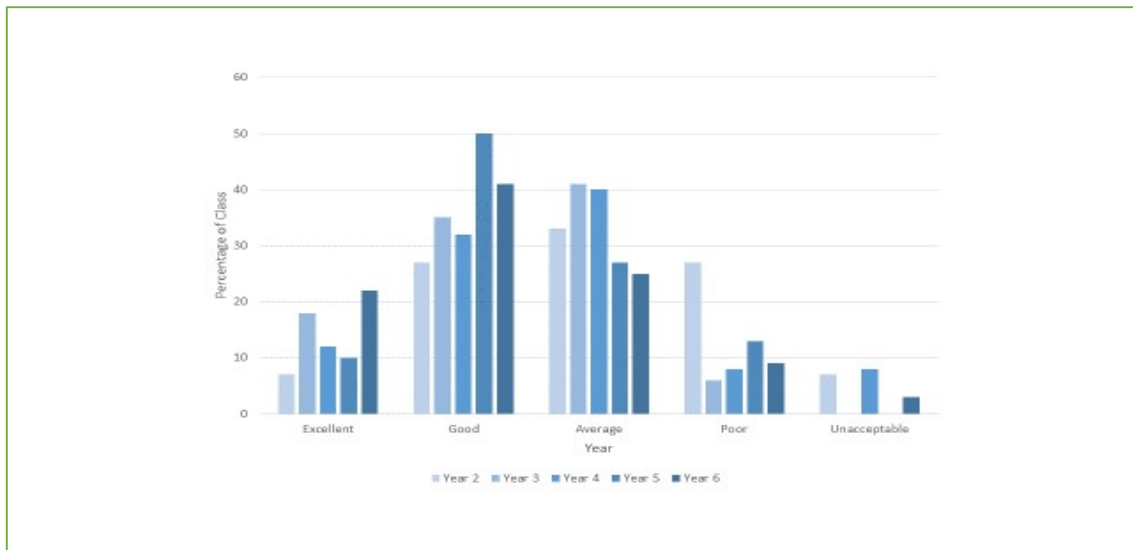


Figure 15: Ratings relative to other courses over time.

A hint of criticism was embodied in the statement by Student 6E: "I was very unaware of UCT's current "green" status. I found it interesting and useful to learn about UCT's attempts (or lack of) to promote an environmentally friendly future". Student 6F added: "Having our work being taken seriously enough that the department paid to print our infographics". Another positive was the researcher's knowledge of the subject, which was rated excellent by 83% of the class, and good by 17%. Prior to the course, 50% of the class indicated that their understanding of sustainability issues was "none or slight". After the course, 72% of the class reported that their understanding of these issues was "substantial".

5.3. Description of the Artefact

It was during self-reflection that the author grappled with the challenge of how to synthesise both Theory U (formerly Sh-Ha-Ri) and Butler's Green IS theory into one coherent model. The author had

struggled to write about this, and although developing several peer-reviewed articles (See Appendix A), needed a different mode of thinking to reach a breakthrough. This came during a writer’s circle run by Prof Lucia Thesen where the participants were faced with a set of coloured highlighters, pencils, pens and white paper and urged, in silence, to draw their thesis. An innovative moment happened with this meditative art-making exercise, which resulted in the realisation that both two processes had a common endpoint: outcomes. Starting the drawing from the outcomes and working backwards resulted in the first synthesis of the two models. The exercise also enabled the author to make use of the consolidation tool of “Ockham’s Razor” to “*seek the simplest possible delineation*” (Baskerville & Pries-Heje, 2010, p. 271). The maxim of extracting only what is necessary (i.e. the seed or nucleus or DNA material) from a kernel theory was utilised to create meta-kernel theories, in other words, to extract the essences of the kernel theories. This is shown in as The Green U in Figure 16.

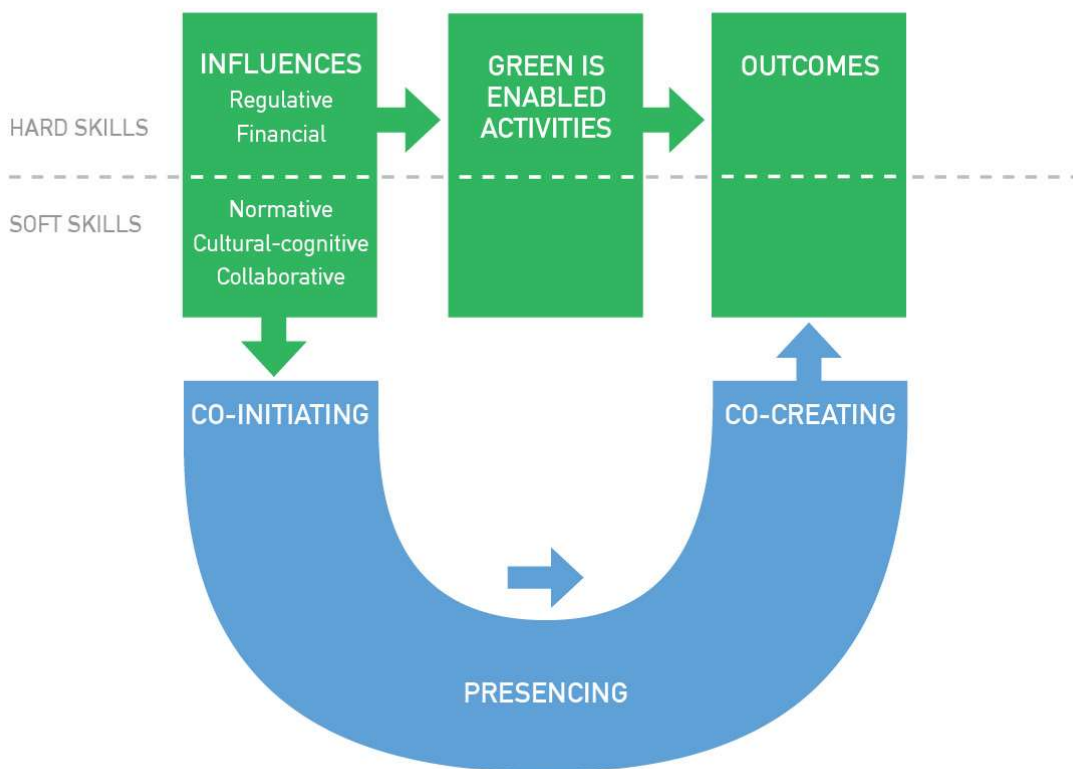


Figure 16: The Green U.

In this case, Butler’s (2011) model was reduced to three key elements: Influences, Green IS enabled Activities and Outcomes. Meanwhile, Scharmer’s Theory U was reduced to the kernels of co-

initiating, presencing and co-creating, thereby maintaining the “U” shape. The Green U draws the top section from Butler’s (2011) model including the influences of Green IS, which he described as Regulative, Normative and Cultural-Cognitive. He based these on Scott’s view of institutions which consist of *“cognitive, normative, and regulative structures and activities that provide stability and meaning to social behaviour”* (Scott, 2001, p. 33). Butler and Daly (2008) describe *Regulative* influences as including rules and laws through which governments and regulatory agencies ensure Green behaviours via the mechanism of coercion.

5.4. Summary

Students were inspired by the dedication of a former UCT student, Lewis Pugh, who has made it his mission in life to be an ambassador for climate change (Schnitzspahn, 2015). As he said, shortly after completing the most Southerly swim on earth in a bid to have the Ross Sea protected: *“I firmly believe the most important issue facing mankind today is the health of our planet. We are driving species to extinction, irreversibly altering ecosystems and leaving our children with an unsustainable world”* (Schnitzspahn, 2015). Later, when the Ross Sea was declared a Marine Protected Area, he said this was *“an issue of justice between generations and between ourselves and the animal kingdom”* (University of Cape Town, 2016).

In terms of Design Science Research, it is important to document the formative evaluations, as each intervention incorporated changes unearthed during earlier iterations. During the development of the artefact, the students were asked to evaluate the programme relative to other courses. As was shown in Figure 15, the earliest evaluation attracted few “Excellent” ratings and many “Poor” ratings. By the final year, more than 20% of the class considered the course “Excellent” and less than 10% considered that it was “Poor”. This signifies that the quality of the course appeared to have improved over time, alongside the development of the Green U.

Chapter Six - Summative Evaluation

6.1 Introduction

The artefact that emerged in the previous chapter was the Green U, a new model for integrating Green IS into the curriculum. In terms of Design Science Research, it is not sufficient to merely develop an artefact – it also needs to be evaluated (Gregor & Hevner, 2013; Johannesson & Perjons, 2014). This chapter also responds to the call for expanding the evidence base of sustainability interventions through applying and contextualising a comprehensive evaluation scheme (Luederitz et al., 2016). Evaluation ensures the rigour of the research if it is done according to accepted guidelines. Hence the author follows the process outlined by Venable et al. (2016), which includes four steps shown in Figure 17 below. The steps include goal setting, strategy selection, criteria determination, and evaluation design. These four elements will now be unpacked in detail, followed by a description of the summative evaluation event, findings, and ultimately, the summary.

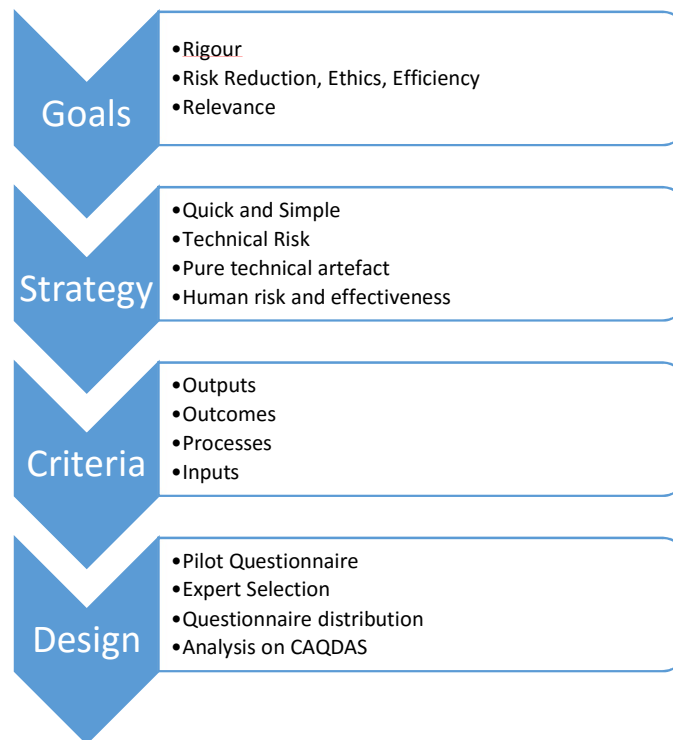


Figure 17: Four steps of an evaluation framework for Design Science (Venable et al., 2016).

6.2 Framework for Evaluation in Design Science

6.2.1 Goal Setting

It will be recalled that the research problem for this thesis was how to incorporate Green IS into the curriculum and it is this resultant model, which subsequently requires assessment. According to Venable et al. (2016), there are several possible goals for evaluating the artefact, and these are *rigour, risk reduction, ethics* and *efficiency*.

Rigour needs to be demonstrated in this thesis, as it is an important criterion for reviewers assessing this research project. There are many definitions of rigour, but one that is useful describes it as a process whereby the researcher uses “*precise, and thorough methods to collect, record, and analyse data. The researcher also takes steps to remain as objective as possible throughout the project*” (Leeny & Ormrod, 2010, p. 157). Evaluations that occur at the end of the project are known as summative evaluations, and they provide the greatest rigour as they produce empirically-based interpretations. In contrast, formative evaluations are intended to produce empirically-based interpretations that support improvements (Venable et al., 2016). In this project, both formative (with students) and summative evaluations were conducted to achieve a high level of rigour. The goal of this particular chapter is to provide a summative evaluation.

Risk reduction is a second possible goal. Risks can be of a human or social nature (Venable, Pries-Heje, & Baskerville, 2016). An example of this may be the risk to the health or safety of participants during the process (Johannesson & Perjons, 2014). The use of formative evaluations acts as early-warning systems, enabling the designer to identify areas for improvement at an early stage, and improve the design of the artefact, while summative evaluations may be helpful at a later stage.

Ethics is a third possible goal of research studies which need to be cognisant of potential harm to participants. This is an important goal, and it has been addressed in detail in chapter four. Through protecting the anonymity of the participants and maintaining records in safe-keeping in the IS Department at UCT, it is clear that ethical considerations are important.

A fourth goal described by Venable et al. (2016) is *Efficiency*. Efficient evaluation takes into account the resources such as time and money, which are spent during the assessment. Again, formative evaluations may help to reduce costs by highlighting potential problems at an early stage. In this case, formative evaluations, which were conducted as part of class evaluations could be regarded as

efficient, as they were built into the course programme and did not incur further costs in terms of time or money.

The author proposes a fifth possible objective: *Relevance*, based on the following motivation. Relevance is a goal which is increasingly important in IS research as proposed by a range of authors (Becker, vom Brocke, Heddier, & Seidel, 2015) who identify a number of challenges for the discipline, including the issue of sustainability. Evaluation of the artefact should be linked not only to the research problem, but a goal should be to undertake evaluations that are relevant to the important societal themes. Hence the evaluation events needed to link to criteria which would enhance the sustainability agenda.

At this stage, two goals were identified, namely Rigour, as this was a requirement for the validity of the study and Relevance, as this was a response to the call for IS research to address focuses on relevant challenges (Seidel et al., 2017).

6.2.2 Strategy Selection

The next step was to select an evaluation strategy, based on the circumstances surrounding the selection criteria. Four options outlined by Venable et al. (2016) were considered. The first, described in a self-explanatory manner as *Quick and Simple*, was considered inappropriate for study validity as it lacked comprehensiveness. The *Technical Risk and Efficacy* strategy was also inappropriate as the design was not technical in nature. Thirdly, a strategy for a *Purely Technical Artefact*, with no social aspects, was not appropriate as there were a number of social aspects involving students and staff.

The final candidate, namely *Human Risk and Effectiveness*, focuses on multiple formative iterative evaluations by real users in real contexts, moving towards summative evaluations near the end. This strategy includes the benefits of evaluating the artefact within an organisational setting, bearing in mind the social difficulties of adoption and use. This was selected as it involved real users (students) in real contexts (the university campus). It was considered the most appropriate strategy as it was relatively cheap to evaluate and there was a potential benefit which “*could continue in real situations over the long run*” (Venable et al., 2016, p. 82).

6.2.3 Determining the Properties to Evaluate

This step was undertaken to choose the specific criteria that would be subject to evaluation. These

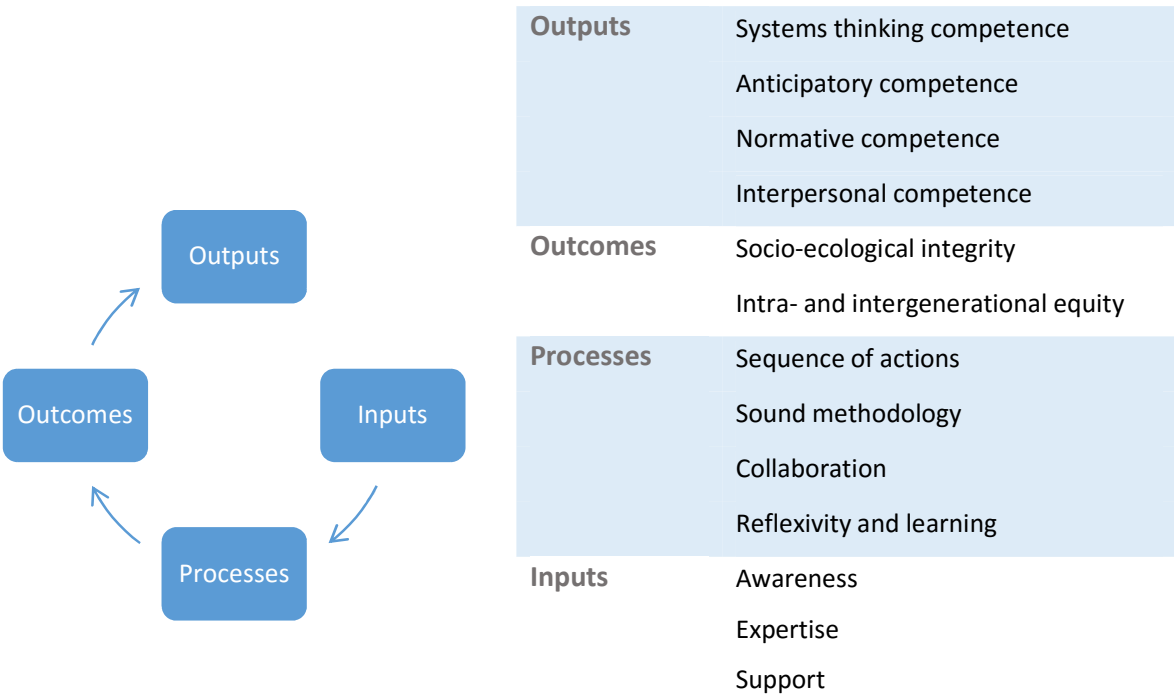


Figure 18: Categories of criteria for evaluation, based on Luederitz et al., 2016 and Wiek et al., 2015.

needed to be chosen to reflect unique attributes of the artefact and a broad range of properties were available for consideration (Gregor & Hevner, 2013), and shown in Figure 18.

In determining which criteria to include it was considered appropriate to follow the guidance of Luederitz et al. (2016) who developed an evaluative scheme for sustainability transition experiments which relate to outputs, outcomes, processes and inputs as shown in Figure 18. The criteria were assessed in the reverse of the logical, clockwise route. In other words, the evaluations were described as follows – outputs, outcomes, processes and inputs. This counter-clockwise order was explicitly created to prioritise outputs. This prioritisation enabled a focus on the results of sustainability experiments and therefore addressed first, as opposed to the more traditional route, from inputs to outputs (Luederitz et al., 2016).

6.2.4 Evaluation Design

The evaluation questionnaire was designed over a period of three months, which enabled rigour to be built into the process via consultation with experts and application of a pilot study. The

evaluation questionnaire was created by adapting a generic evaluative scheme for sustainability transition experiments (Luederitz et al., 2016) which was comprehensive and operational. This served as the basis for structured reflection with an educational expert, utilising open-ended questions.

Through correspondence with Luederitz (2016) further contextualization of the questionnaire was recommended. He wrote: *“In the case of an experiment that looks at education one could divide the feature 'build capacities' into the sub-categories of 'systems-thinking competence', 'anticipatory competence', 'normative competence', 'strategic competence', and 'interpersonal competence'...”* (Luederitz, 2017, p. 1). These competences were based on prior studies for sustainability capacity building in Higher Education (Wiek et al., 2015).

These criteria were adopted, with the exception of strategic competence, which was seen to be outside the scope of the research project, as the students did not have the capacity to action their recommendations and also their understanding of strategy was considered to be outside the life-experience of computer science undergraduate students. The strategic competence would have enabled students to *“develop and test systemic interventions, transformational actions and transition strategies toward sustainability, accounting for unintended consequences and cascading effects. They are able to develop plans that leverage assets, mobilise resources, and co-ordinate stakeholders to overcome systemic inertia, path dependencies and other barriers to reach envisioned outcomes”* (Wiek et al., 2015, p. 247). This competence goes beyond the scope of a semester-long course, so this criterion was not included in the final questionnaire.

A pilot study was conducted with an expert on sustainability education. She made important recommendations, including the need to explain the model in more depth. This added another layer of rigour to the development of the instrument. Following this, the researcher approached six potential assessors with expert knowledge of the project (participant observers) on the sustainability course. The evaluators included a Sustainability Expert (SE), Education Experts (EE1 and EE2), and a Student Sustainability Expert (SSE). These identifying tags (SE, EE, SSE) were applied in the qualitative analysis software Atlas-ti and documented as Evaluator Profile Excerpts. The evaluation questionnaire is included as Appendix B. Two evaluators, (EE3 and SE2), declined due to time constraints. In addition to being participant observers of the course (as lecturers, examiners or students) the evaluators were given a range of data sources including the course outline, student evaluations and a portfolio relating to the course. Although the evaluators had the benefit of having

lived through the experience of the course, a possible criticism is that this would make them lose objectivity. They were invited to comment on 13 different criteria as well as apply a score out of 10 for each item. The evaluators completed the assessment electronically or verbally (with interviews transcribed). Evaluations and permission letters were kept in the IS department for safekeeping in line with the university’s ethics requirements.

6.3 Findings and Analysis

The evaluation event first identified outputs related to capacity building of a range of competences that empowered the students to internalise required skills and activate new behavioural patterns

Table 10: Co-occurrence analysis of outputs compared with other factors from Atlas-ti.

	Outputs				
	Anticipatory competence	Interpersonal competence	Normative competence	Systems Thinking	Totals
Awareness	0.28	0.29	0.23	0.08	0.87
Collaboration	0.11	0.28	0.1	0.05	0.53
Equity	0.1	0.14	0.04	0	0.28
Expertise	0.1	0.11	0.09	0	0.3
Integrity	0.03	0.03	0.1	0.1	0.26
Method	0.03	0.07	0.04	0	0.13
Reflexivity & learning	0.14	0.19	0.11	0.04	0.48
Sequence	0.03	0.08	0.04	0	0.15
Support	0	0	0	0	0

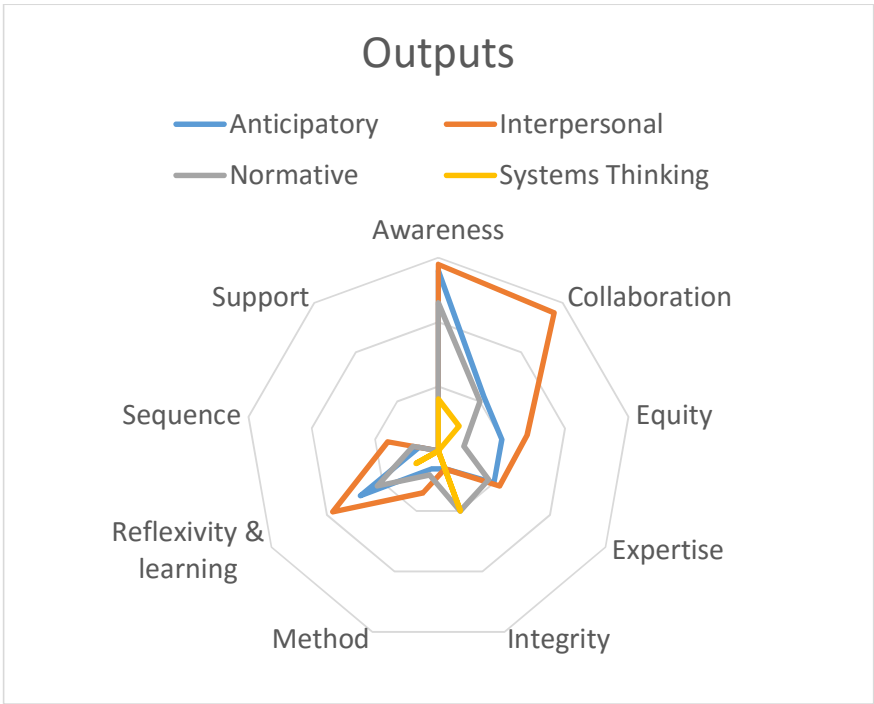


Figure 19: Relationships between outputs and other criteria based on co-occurrence analysis.

The study explored how the course linked to the model had enabled students to generate sustainability solutions via systems thinking, anticipatory competence, normative competence and interpersonal competence (Wiek et al., 2015). A co-occurrence analysis is shown in Table 10 to illustrate the linkages between outputs and other factors and shown graphically in Figure 19. Each of the criteria will now be discussed.

6.3.1 Systems Thinking

Systems-thinking competence is the ability to analyse complex systems on a broad scale of structures, patterns, feedback loops and other systemic features (Luederitz et al., 2016). Evaluators were asked: How successful do you think the process is at building systems thinking in students?

The evaluators noted that the project encouraged them to look holistically at the issue on a broad scale (McNamara, 2006). *“For this broad perspective students had to consider the immediate environment of the particular project within UCT as well as the external environment”* (EE1).

In addition, students on the course had to search for sustainability solutions. *“This search was driven by exploring and finding creative ways of identifying structures, patterns and cycles in the current systems that would help them to identify issues of concern and propose solutions to those. A systems-thinking approach helped students to appreciate the complexity of real-world situations of concern. The real-world project made them further realise that the ‘happy day’ scenarios often presented in textbooks are not the norm”* (EE1). Another evaluator supported this view: *“The carbon footprint methodology includes both direct and indirect emissions, so one has to think of the whole system. There are also various elements to gathering information to complete the project, so the university as a system is considered. However, the topic of environmental sustainability is quite broad, and there are many elements to it – not all of them are (or possibly can be) taught or considered in one IS course. Some lecturers ... discuss systems thinking explicitly when they present”* (SSE).

However, a limitation was noted: *“This score would be higher if the student's groups had greater involvement or exposure to the full range of activities across scopes that are measured for the UCT carbon emissions. This competence is one that takes time and experience to develop”* (SE).

6.3.2 Anticipatory Competence

Anticipatory competence or “futures thinking” is the ability to anticipate how sustainability issues may evolve over time (Wiek et al., 2015, p. 244) for which the question posed was: how successful do you think the process is at building anticipatory competence in students?

One evaluator described how this competence was developed: *“During each delivery of the course, students with almost no or very little knowledge and experience of sustainability issues are confronted with these issues in a way that they cannot ignore them or brush them aside anymore. This requires them to make sense of and interpret the current situation in a particular context that will foster knowledge gain and a deeper understanding of this situation. Through this process, they gain experience to develop a deeper awareness and appreciation of sustainability issues”* (EE1).

This was confirmed by students: *“I’ve become more aware of the different environmental issues on our campus. Our campus can play a huge role in either polluting the community or serving as an example of how to properly behave in an eco-friendly manner”* (ST2B).

Referring to the lateral thinking tool of wearing different coloured hats for different thinking styles *“I was trying to come up with a creative idea that would stick out of the rest and therefore I was the green hat wearer”* (ST1C).

Other evaluators concurred. *“The guest lecturers do a good job in explaining climate change and contextualising sustainability. However, the focus of the carbon footprint report is narrower, as it only relates to emissions, at UCT, for a one year period. More can be done to help students come up with feasible recommendations”* (SSE).

6.3.3 Normative Competence

Normative competence is the ability to collectively assess the unsustainability of current campus operations and make recommendations on how to make UCT more sustainable. Evaluators were asked: How successful do you think the process is at building normative capacity in students? Answers were congruent. One evaluator observed how some students developed insights: *“The exercise of making recommendations does build the capacity to assess current campus sustainability. Some of the recommendations made by students are creative, and at times insightful. At the presentations, some students display a strong passion to contribute to improvements on campus”* (SE).

Another evaluator remarked how the longitudinal study facilitated long-term benefits: *“The iterative process and the consecutive deliveries of this course from 2011 to 2016, focusing on improving and adding to the previous year’s carbon footprint results, created a collective responsibility amongst the students towards the sustainability of the campus operations. This meant that they took the ‘baton’ so to speak from the previous year’s students. They could visualise the effects of this continued collaboration with the different stakeholders linking theory and*

practice” (EE1).

The student evaluator concurred: *“This is a core part of the project and has been emphasised more in recent years. This is a very important part of coming up with a carbon footprint report – besides the numbers and facts, creative and feasible recommendations based on the results are vital”* (SSE).

6.3.4 Interpersonal Competence

Interpersonal competence is the ability to motivate, enable and facilitate collaborative work. It is defined as follows: *“Graduates with interpersonal competence are able to initiate, facilitate and support different types of collaboration, including teamwork and stakeholder engagement, in sustainability efforts ... They are able to incorporate and complement the experiences and expertise of others when working in or leading teams in professional settings; in addition, they are able to successfully collaborate with various stakeholders from government, business and civil society. In these functions, graduates are skilful in communication, pluralist (trans-cultural) and empathetic understanding, deliberation, negotiation and leadership”* (Wiek et al., 2015, p. 250).

The question posed was: How successful do you think the process is at building interpersonal competence in students?

The sustainability expert rated this competence highly. She wrote: *“This process is sometimes the first experience for students of working in groups of this size (5) and diversity of discipline, culture and educational backgrounds. They go through a rapid and steep learning curve. The course thus builds this competence from a low base and results in new awareness of both challenges and benefits of group work, interdisciplinary thinking and diversity. At the end of the process, the students clearly have developed their understanding of the need for attention to, and management of, the dynamics of group work* (SE).

Communication was identified as a key feature by another evaluator: *“Each team, often with members from different countries, communities and different backgrounds and where members further have different perspectives and an appreciation for different approaches, is forced to create a shared experience while working on their project. Elements of interpersonal competence addressing students’ attitude and behaviour are nurtured through communication with stakeholders”* (EE1).

6.3.5 Socio-ecological Integrity

The concept of socio-ecological integrity has been described as the integration of both human and natural systems and is based on human judgement (Flucker, 2010). In the UCT context, this involves harmonising the wellbeing of both the campus community and its ecosystem. The question posed

here was: How successful do you think the process is in creating socio-ecological integrity on campus?

This appeared to be one of the least effective outcomes. The limitations of the project were evident to the sustainability expert who wrote: *“Due to the immense size of the university community, lack of time for broader engagement; or for greater survey sample sizes, this group of approximately 40 students is not able to make a significant impact on the campus. However, this course leads by example, and if such approaches were more widespread in other curricula, the impact at campus level could be greater”* (SE).

A positive factor included an education expert’s perspective: *“Outputs of this course for 2011 cycle were the student reports with their findings and recommendations on the energy consumption in selected computer laboratories as well as paper consumption constitutes efforts to harmonise the campus community and its ecosystem. Unfortunately, there was no follow up to see whether these recommendations were implemented ... On the course, there was an emphasis on making students understand the objectives of the project and tying this up with the mission and vision of the university. There was an attempt to understand that the university wanted to create African leaders and show an example, not only by what it preaches but by what it does. The intervention had to tap into this. I don’t think most of the students got that, but in the introduction to their projects showed that the organisational objectives and project’s objectives were linked”* (EE2).

The development of a network across campus and the building of valuable relationships contributed to strengthening the ecosystem and to a closer-knit campus community sharing the same focus. The process of building a network was not without challenges. It was difficult to get buy-in from all stakeholders, which caused the project to be less successful in many areas, such as in garnering top support in following the student recommendations. For example, each year the energy saving recommendations were compiled by the sustainability consultant into a report which did not always receive a high priority and for which the recommendations were not implemented.

6.3.6 Intra- and Intergenerational Equity

The notion of intergenerational equity is derived from economics, where it was argued that planetary resources are not inexhaustible and current generations need to consider the needs of future generations (Solow, 1974). Intra-generational equity refers to social transformation issues within the existing generation (Mattioli, 2013). In terms of UCT, this criterion involves attempting to reduce gaps between the rich and the poor and enhance the ability of future generations to pursue

sustainable lives. The question posed to evaluators was this: How successful do you think the process is at building equity?

Again, the evaluators were sceptical of the course achieving this outcome. One of the education evaluators noted: *"There was a deeper conversation needed here. When we asked them to be reflective, there were aspects of critical thinking, but it was a small part of the course, and we didn't get enough opportunity to engage with that and for it to get embodied"* (EE2).

The student expert wrote: *"Sustainability also does not seem to be mainstream here, yet. Therefore, not many people think about future generations and the impact that past and present generations have/are creating. This is a difficult topic that can and should be explored further"* (SSE). This view was shared by the sustainability expert: *"Again this score is due to small class size; however, over time the course does reach a growing number of students who may go on to integrate sustainability practices in their work and lives"* (SE).

Despite the limitation, it was noted that the *"Course has potential to begin a process of ongoing learning towards leading sustainable lives"* (SE). This had the backing of a student: *"I found it interesting and useful to learn about UCT's attempts (or lack of) to promote an environmentally friendly future"* (ST6E).

6.3.7 Sequence of Actions

This involves a structured and rigorous chain of activities in the learning and teaching process and assessors was asked: How successful do you think the process is at sequencing actions? Scores for this were relatively high. An education expert observed: *"There was a good attempt in making sure that the students are exposed to the problem, talk to people and then half way through, introduce the concept of reflection. It was deliberately put there so that when they came to reflection, they had meat to engage with, from their team experiences and talking to people. Then they got theories to help them interpret that and the opportunity to change some of their practices"* (EE2).

Another evaluator concurred: *"A very well structured course, it commences with a detailed plan of activities for the semester. Students are required to produce a Gantt chart timeline and meet each interim deliverable"* (SE). Another education expert made similar findings. She wrote: *"The course endeavoured to 'foster in our graduates' personal qualities such as intellectual autonomy and ethical and professional habits of mind' ... Cockburn's ... principles representing three stages of behaviour of 'follow, detach and fluency' were used to design a range of different interventions for each one of*

these stages. These interventions were used to guide the students through a learning path where they could transcend through different stages of skills acquisition. The interventions for each particular stage, challenged students to move to the next level of competency and skills acquisition. Students can be at different stages for various interventions. In addition to this, every annual delivery had a particular focus ensuring that a holistic approach was preserved. For example, in 2014 the focus of the holistic approach was on visualisation where each student team had to produce a comprehensive infographic to illustrate and represent the outcomes and impact of their specific project. The sequence of actions taken throughout each delivery of the course was successful in nurturing different student attributes like behaviour and attitudes, learning and higher order learning, skills and real world experience through a complex environment of linking theory and practice” (EE1).

6.3.8 Sound Methodology

Sound methodology involves a structured approach, including monitoring and evaluation. The question was: How successful do you think the process is in terms of soundness of methodology?

An education evaluator reflected on the strong structured basis for the course. She wrote: *“The pedagogy of a coherent practice addresses the limitations of the IS Curriculum, creates an awareness of the complex reality of real-world projects and is supported by kernel theories. These theories helped the understanding and sense-making for deep approaches to learning and aided the design of the interventions. In addition to these behavioural science theories, Butler’s Green IS theory and later the adapted theory contributed to the kernel theories and aided the development a Green IS model.*

Seven core elements formed the physical building blocks of the curriculum for the past 6 years. These were the key areas that defined the course content; the stakeholders as fundamental role players; several core issues that were addressed like developing Green IS theories; the outputs and impact of the course to monitor the well-being of what was developed and achieved; student outcomes to monitor students’ transcendence through stages of skills acquisition; the assessment practices implemented to formalise the evaluation as well as the different interventions for teaching and learning.

During the evolution of the course, the methodology as described above formed an intrinsic part to conceptualise, articulate and facilitate the creation of contextual knowledge - activities that are inherently part of the IS discipline. This course based on sound methodology manifested as an exemplar of research led teaching” (EE1).

6.3.9 Collaboration

This construct is concerned with collaborative opportunities for students and staff to ensure empowerment of participants. This is the question that was posed: How successful do you think the process is in creating collaborative processes?

The sustainability expert was impressed with this element and scored it highly. She said: *“The Technical Workshop is an excellent opportunity for collaboration between students and staff/guest lecturers. It also serves as a good dialogue point within student groups. The timing of this event within the process/semester is critical to maximize fruitful collaboration. The course Convenor has an open door policy and provides strong mentoring to students. Tutors were introduced ... towards further supporting and empowering students. The student group work model is itself a good opportunity for enhancing collaboration skills and experience”* (SE).

This view was supported by an education expert. *“Although collaboration both internally and externally on various platforms provided rich experiences to both students and staff, this also accounted for many challenges over the lifecycle of the course. Despite working external sustainability organisations, with Anthony Dane from UCT’s Energy Research Centre (ERC) in 2013 and the invaluable support from Sandra Rippon, UCT’s sustainability consultant, who collated the student carbon footprint results into three institutional reports since 2012, it was difficult garnering UCT support for the project. Proposals from the students were not always implemented, for example, every year energy saving recommendations were made, which were not implemented.*

On other fronts collaboration was more successful. The course was highly regarded as part of the research led teaching strategy by deputy vice chancellor Sandra Kloppers and the team presented the teaching philosophy at the internal teaching and learning events of the university In 2015 the team received the UCT Award for Collaborative Educational Practice (CEP) to the value of R30 000. During the same year, the team also won the national excellence in teaching and learning team award from the Higher Education Learning and Teaching Association of Southern Africa (Heltasa). Several joint research papers were presented at international conferences and publications in international journals. A special recognition from the World Economic Forum in Davos, Switzerland, was received, where this course was nominated as a Best Practice Case Study” (EE1).

6.3.10 Reflexivity and Learning

This criterion involves continuous analysis of actions as well as iterative learning. Assessors were asked: How successful do you think the process had been at fostering reflexivity and learning?

Students gave insightful comments on what this criterion meant to them. One wrote: *“Reflecting encouraged me to look at this project with a different perspective and positive attitude, helping me to better understand my team members. I feel that I have grown as an individual, and look forward to working on many more group projects in the future”* (ST4A).

This construct received the highest score from the sustainability expert who wrote: *“Again, a new concept and experience for many of the students. A rapid learning curve. Group dynamics appear to generate much for students to reflect upon. Apparent at the final presentations that students have had a powerful, deep experience of reflexivity, without which the lessons learned would not be as well embedded”* (SE).

This was corroborated by this personal correspondence from former Dean, Professor Don Ross who made the links between learning and theory: *“The pedagogy incorporated in the course design is explicitly reflective of best theory. It is developed on the basis of a deep understanding of Alistair Cockburn’s Shu Ha Ri progression for learning to design and use agile software. The students are self-consciously taken through the three stages of the progression. This development methodology is enriched by the project team’s alertness to the philosophy of coherent practice design that has its roots in Dreyfus & Dreyfus’s cognitive science of learning, which in turn has its deep foundations in the pedagogical phenomenology of Merleau-Ponty. The course thus exemplifies the rigorously conceptualized approach to practical skill teaching that one hopes to find, but too often does not, in a senior course at a research-led university”* (Ross, 2015).

6.3.11 Awareness

This construct involves changing students’ awareness of sustainability issues. The evaluators were asked: How successful do you think the process is at building sustainability awareness in students?

Although evaluators scored this highly, one noted that *“Score here would be higher if the students were more exposed to the holistic overview of the entire carbon footprint. The groups appear not to interact, even when topics are closely aligned (perhaps due to time constraints). With respect to the topic of each group, there is a very strong increase in awareness. The context given by the guest expert’s lecture – local, national and international carbon reporting practices is valuable here”* (SE).

Another evaluator observed: *“Through these shared experiences students are empowered with an intense awareness of the sustainability issues around them, becoming more responsible in their own activities towards the environment. Students commented on using energy resources and commodities like paper and water more responsibly. They thought twice before using cars instead of the Jammie shuttles or walked instead of driving.”* (EE1).

This was endorsed by a student: *“People know about recycling and the bin system, but no one knows about the emissions produced by the vehicles, or the amount of e-waste we produce. So the project has actually educated me in other areas that I have never been taught about in high school or varsity”* (ST6C).

It was also echoed in this comment from the Dean: *“The course directly engages the lived experience of the students. As members of the elite segment of their society who attend its top university, students at UCT are already leaving larger than average carbon footprints through their daily routines. In compiling and measuring the University’s carbon footprint, they are studying a social impact of their own familiar habits and behaviours, since students are the main direct producers of that footprint, and while the parts of it they don’t produce directly themselves are produced on their behalf. Thus, mitigation also falls within their circle of control. If such knowledge is to change behaviour, it must not be entirely or mainly abstract, but encountered in life. The students in the carbon footprint course are brought directly into contact with the environmental significance of their own routines, and thereby empowered to take responsibility for it and seek to control it”* (Ross, 2015).

6.3.12 Expertise

This criterion concerns the input of expert sustainability knowledge from well-recognised professionals. Evaluators were asked: How successful do you think the process was at utilising sustainability experts?

Specific expertise was provided by external and internal sources. An education evaluator noted: *“We always tried to get an expert. We brought in the ERC as experts. There was an attempt to link with them, but in fact it came down to an individual rather than a partnership. We brought in experts from outside companies to engage in outside issues. Sandra Rippon provided the link between academia and the data holders. In terms of her long-term perspective, her role was crucial, in that we couldn’t do anything without her”* (EE2).

The student evaluator would have preferred a greater number of experts. However, another evaluator conceded: *“This course has higher than average expert inputs and within the time constraints, and balancing with other teaching inputs, it would not be possible to do much more”* (SE).

6.3.13 Support

The support construct concerns the structural, financial and non-financial resources from the host university. The question here was: Does the process secure sufficient support?

Again, this criterion was identified as a major deficiency. One evaluator observed: *“It took hard work to convince the property and service sectors in the University of the added value that the student projects research and findings can contribute towards the overall sustainability reports. Financial resources were limited, with only two grants that were received ... These grants helped to pay for basic costs at events as well as the sustainability consultant services, when assisting student teams”* (EE1).

However, on the pedagogical side, *“The recognition of teaching excellence from the university is a positive contribution”* (SE).

6.4 Summary

The purpose of this chapter was to set out the summative evaluation methodology, which followed a series of formative evaluations in the previous chapter. In that section, 183 students gave evaluations of the course. In this section, four expert evaluators gave their assessments. This chapter explored a framework for evaluation in design setting, where goals were set, strategy selected and criteria for evaluation were determined. This led to the evaluation event, a digital questionnaire, which was completed by a sustainability expert, two education experts and a student sustainability expert.

The findings show that the most successful components of the course were interpersonal competence, collaboration, awareness raising, as well as reflexivity and learning. Other noteworthy successes included the sound methodology and sequence of actions, underscoring the rigour of the process. Deficiencies were noted in the areas of socio-ecological integrity and equity. Support from the university was identified as the greatest shortfall. A discussion of the results, within the context of UCT, will be elaborated in greater detail in the following chapter.

Chapter Seven – Discussion and Theoretical elaboration

7.1 Introduction

One of the important observations in chapter six was that the Green U model led to a range of outcomes, outputs, processes and inputs. The function of the current chapter is to build a discussion around these elements. To achieve this aim, the author will first position the discussion within the organisational context of the case study. Next, linkages between various aspects of the evaluation will be examined via co-occurrence analyses. Finally, the author will discuss how the findings can enhance the discipline's understanding of sustainability education dynamics.

7. 2 Organisational Context

The setting was the University of Cape Town, which was chosen as an exemplar. UCT is unique in many respects. It is regularly featured as the top university in Africa and is also the oldest institution of its kind in South Africa. The main campus abuts the Eastern slope of the magnificent Table Mountain range, a world heritage site that is also home to a range of endangered flora and fauna. Students can gaze out of a lecture hall window at a spectacular mountain peak covered in indigenous fynbos species and be intimately linked to the cycles of nature. It is no surprise then that students and staff have had a history of involvement with sustainability issues on campus.

Indeed, the Science Faculty, who has been home to numerous Nobel Prize winners, has had a long engagement with environmental issues, particularly with regard to biodiversity and climate change issues. The first institutional response was in 1990 when the incumbent Vice-Chancellor, Dr Stuart Saunders, was part of a global initiative known as the Talloires Declaration. It was in Talloires, France, where campus leadership made a formal commitment to incorporate sustainability into Higher Education. This document was subsequently signed by more than 390 university leaders across 40 countries (Adlong, 2013). However, the timing was not opportune for UCT to implement this commitment. It will be remembered that the 90s were the last days of the Apartheid era and the birth of the new democracy and political transformation was highest on the agenda. Thus, at UCT, the Talloires Declaration gathered dust.

Another Vice-Chancellor who put sustainability back on the agenda was Professor Njabulo Ndebele who called for committed action. In 2007, students in the Botany Department took the lead to develop the Green Campus Initiative (GCI). They were concerned that a 3° rise in temperature, due to climate change, would have devastating consequences for the country's plant and animal life. This was subsequently confirmed by researchers who found that the Cape's unique fynbos would be negatively impacted by climate change (Slingsby et al., 2017).

UCT, which had played a leadership role in political change, now had the opportunity to take the lead in sustainability change. The GCI proposed a Green Campus Unit, a multi-disciplinary body of academics and administrators who argued that the energy savings incurred by the project would cover the unit's costs. The goals were to *"Determine the total greenhouse gas (GHG) footprint of UCT ... Set a greenhouse gas reduction target ... Prepare and implement a GHG reduction project ... Develop the use of UCT as a living laboratory for educational purposes ... Develop educational programmes that will achieve campus environmental impact reduction"* (Hall & Murray, 2008, p. 8). However, at the time of writing in 2018, this proposal had not been implemented.

Again, it was a student who created the next step, monitoring UCT's carbon footprint. Lesotho-born Engineering student Thapelo Letete was doing his Master's Degree and spent two years collating relevant data. He noted that the measurement of UCT's footprint was long overdue and fraught with challenges, notably the difficulty with data gathering (Letete et al., 2011). His team found that electricity accounted for 81% of the total carbon footprint of UCT in 2007 (Letete et al., 2011).

Subsequently, in a landmark decision, the Vice-Chancellor Dr Max Price signed an international agreement committing the university to report on its carbon footprint and other sustainability metrics on a regular basis through the International Sustainable Campus Network / Global University Leadership Forum (ISCN, 2010). As the campus did not have a sustainability office, it was left to a trio of postgraduate students to pick up the mantle to create a collaborative network of researchers, lecturers, students and administrative staff to measure sustainability metrics collated into the campus carbon footprint. This then set the context for the Green IS research project, which started in 2011.

The Department of IS in the Faculty of Commerce was running a semester-long project management course for Computer Science students in the Faculty of Science. The convenor of this course was looking for a real-world project to give to the students on an annual basis, and the possibility of

integrating Green IS into the curriculum became a win: win situation for administrative staff, researchers, lecturers and students, as well as the university as a whole. Carbon Footprinting was selected as a proxy for sustainability, as it enabled students to engage with a range of issues, including energy consumption, water, waste, commuting, flights, food, use of liquefied petroleum gas in the labs and other topics. A critique of Carbon Footprinting is that equally important issues such as biodiversity loss and conservation of other natural resources were neglected from this frame. The issue of sustainability was also clearly linked to the nascent subfield of Green IS, which takes a systems-view that incorporates human and technological actors, data and processes in pursuit of sustainability objectives. Given that Green IS provides a wealth of material for IS educators to enrich their teaching (Topi, 2012) and this research responds to a call to develop sustainability courses, the researcher set about drawing on theories of teaching and learning to provide students with robust, well-delivered, challenging, holistic learning experience (Lozano et al., 2014). This is the context that now frames the discussion.

7.3 Findings from the Empirical Analysis: Outputs

As will be recalled from a previous chapter, the suggestion was made to invert the usual input-process-output-outcomes process, and to prioritise outputs as a way of helping to shift thinking to a more impactful sequence (Luederitz et al., 2016). Hence the sequence will be discussed in line with the format illustrated in Figure 20.



Figure 20: Sequence of summative evaluation elements (based on Luederitz et al., 2016).

The empirical analysis in this thesis yielded a total of 227 relevant observations, which formed the basis of the following discussion. As noted earlier, a model for incorporating sustainability into the curriculum was developed over six iterations, and the empirical analysis of the final evaluation showed that the process had been relatively successful in creating a range of outputs. These are shown in Table 11 where it can be seen that the strongest feature is normative competence (74 instances), and interpersonal competence (73 occurrences). This is followed by anticipatory competence (63 observations), and systems thinking competence (17 instances). Also of interest is the correlation between the evaluation criteria in the rows and the output competences in the columns according to the analysis conducted on Atlas-ti. This shows that the greatest numbers of

linkages are between normative competence and collaboration. The lowest number of linkages is shown by the support criterion, indicating that this was not well developed in the process.

Table 11: Summary of linkages between criteria

Evaluation criteria	Outputs: Competences				Total
	Anticipatory	Interpersonal	Normative	Systems Thinking	
Anticipatory competence	0	12	15	4	
Awareness	11	14	9	2	
Collaboration	3	1	24	0	
Equity	3	6	1	0	
Expertise	3	5	2	0	
Integrity	3	1	2	4	
Interpersonal competence	12	0	12	4	
Method	1	3	1	0	
Normative competence	15	12	0	2	
Reflexivity and learning	7	12	5	1	
Sequence	1	3	1	0	
Support	0	0	0	0	
Systems Thinking	4	4	2	0	
Totals	63	73	74	17	227

7.3.1 Interpersonal Competence

This issue of interpersonal competency had been identified as an issue prior to the introduction of the sustainability project management course, and so the course co-ordinators were able to build on prior experience. A range of readings were introduced that enabled students to make sense of interpersonal dynamics, such as the diversity of viewpoints embodied in the thinking hats theory (De Bono, 1990) as well as reflective practice (Jordi, 2011). This was extended with reflection on Green IS theory and practice.

Reflection constituted a golden thread for build sustainability capacity both in the interpersonal issues within their teams as well as with stakeholder. This was noted by one of the evaluators (EE1), and also by students. *“One of the novel things introduced in this course was to have students reflect and understand the process of reflecting. It was hard for ComSci students, but in the end they were able to appreciate the ability to interpret their actions. It doesn’t work if they reflect in a vacuum. Thinking hats and the conflict resolution tools were key ingredients in the Reflection process and were critical in helping them to deal with issues as a team and the interaction with stakeholders. We*

are living in a very complex society, and Reflection gave them the ability to engage with difficult aspects – part of their identity and negotiating with other human beings” (EE2). This idea of building their own identity and recognition of the value of others provided a unique learning experience for the students. Student ST3A observed: “Reflection constitutes the ability to uncover and make explicit to oneself what one has planned, observed, or achieved in practice. Applying this to a group is more of a challenge than applying it to an individual, but it is certainly more interesting because of the colourful personalities that make up a group and the group dynamics that develop and evolve over the lifetime of the group”.

As ST2B noted the value of interpersonal competences in building harmony in the team as well as the value and richness of diverse viewpoints: *“This module gave me a perspective on how to view different situations in everyday life. It helped our team to move forward and to also work in harmony with each other. It taught me the importance of viewing and respecting other people’s opinions and to realise that different people bring different hats to the table. That having team members with different ideas is not as bad as it seems. I’ve learned that diversity brings the best results”.*

Another student made the connection between interpersonal competence and reflective learning. ST2C wrote: *“Having experienced something, and then being able to reflect back and analyse that experience is a key tool in learning which most of the learning peers and teachers seem to have forgotten about. This course set out a perfect structure with one having to reflect the experiences in the duration of the activity. With the help of the readings done in class, one can fully understand their experience and thus trigger the exploration of alternative perspectives, if those before seemed incorrect, and act on new perspectives according to their experiences”.*

This was confirmed by another student: *“Working in teams on interesting projects offers huge room for growth through the development of interpersonal relationships as well as internal emotional development” (ST3B).*

As shown in Table 11, the interpersonal competence, is also highly connected to awareness, collaboration, and reflexivity and learning. This suggests that when students develop interpersonal competences during sustainability education, their awareness, collaboration, reflexivity and learning processes are enhanced.

There is some evidence for this in literature. Lozano, for example, argues that collaboration is key to sustainability *“requiring that all the players, even the silent ones such as the environment and future generations of plants, animals and humans, communicate, become highly involved and learn from each others’ experiences. Each of the players needs to keep an open mind to recognize that the other players, present and future, are different and behave differently, where their needs must be recognized, addressed and fulfilled”* (Lozano, 2007, p. 380).

This has corroboration in the literature as it aligns with recent research into Problem-based and Project-based Learning (PPBL) courses in sustainability. This is a learner-centred approach that empowers students to conduct research, integrates both theory and practice, and develops feasible solutions to specific problems (Savery, 2006). This is supported by the IS undergraduate curricular guidelines, as the IS2010 version states that students need to develop interpersonal skills such as problem-solving in a team (Topi et al., 2010). In addition, Project-Based Learning tends to be a group activity with a timeline, milestones and other formative evaluation steps. The process replicates the commonly used systemic approach to resolving problems or meeting challenges that are encountered in real life (Donnelly & Fitzmaurice, 2005). A recent study found promising PPBL integration into sustainability programs in Europe, North America and Australia. However, challenges remain in defining learning objectives aimed at the acquisition of sustainability competences (Brundiers & Wiek, 2013). Such competencies have been defined as both “basic” competencies such as interpersonal skills as well as strategic and systems thinking competencies (Wiek, Withycombe, & Redman, 2011). This latter competency is ideally suited to the IS curriculum, which encourages students to see the interconnectedness of people, technology, data and processes as a dynamic system. A global study found that PPBL courses showed compliance with key principles including addressing wicked sustainability problems, adopting a focus on developing sustainability solution options and developing teamwork as well as stakeholder collaboration (Brundiers & Wiek, 2013). Furthermore, the promotion of social and institutional learning for sustainable development has been identified as one of the key research themes predicted for the next decade (Miller et al., 2014).

7.3.2. Link between Interpersonal and Key Sustainability Competences

The data in Table 11 show high linkages between interpersonal competences and the critical sustainability skills of normative and anticipatory competences. It will be recalled that the student group comprised third-year computer science students who were highly skilled in hard computing skills. By the end of the course, their normative competence had grown. For example, one student

wrote: *"I must be honest I learnt a lot from the project. I was very ignorant about the environment, but now I am aware of environmental sustainability"* (ST3B).

Anticipatory competence was suggested by another student: *"I realise now that we all have to do our part, if we're to survive longer on this planet"* (ST4D). An education evaluator also made this observation: *"We had a few sessions where we got buy in upfront and the speakers were brilliant at coming up with infographics and images that were impactful in showing the transformation in weather patterns and connection with human affairs – wars, civil wars, unrest ... and their part of not just doing the course, but the bigger challenge at stake. Everything was done in teamwork and we emphasized diversity. Assessments were based on how the team was able to work well together. Any success in obtaining insights was via the ability to engage fellow students. They had no power to coerce, so they had to engage and work as a team"* (EE2).

This has some backing in the literature. An example of this in the field of Problem-based and Project-based Learning (PPBL) where students engage in real-world sustainability problems and attempt to find solutions. Key principles underlying PPBL courses include addressing sustainability problems, focusing on solutions and recognising the need for teamwork and stakeholder collaboration (Brundiers & Wiek, 2013).

7.3.3. Link between Normative and Anticipatory Competence

The data also show strong links between normative competence (to collectively assess the unsustainability of current campus operations and make recommendations on how to make UCT more sustainable) and anticipatory competence (the ability to visualise the future, related to sustainability issues).

This linkage is also shown by the evaluators, for example: *"The iterative process and the consecutive deliveries of this course from 2011 to 2016, focusing on improving and adding to the previous year's carbon footprint results, created a collective responsibility amongst the students towards the sustainability of the campus operations. This meant that they took the 'baton' so to speak from the previous year's students. They could visualise the effects of this continued collaboration with the different stakeholders linking theory and practice in a significant manner"* (EE1).

A search through the literature confirms this. These two elements are complementary and incorporate both an understanding of current unsustainability as well as the ability to envisage

future scenarios (Wals & Corcoran, 2006). This is supported by Adomssent et al. (2007) who defines sustainability competence as the ability to shape future scenarios by active involvement in modelling and transforming society towards sustainable practices. Further support comes from authors who note that envisioning future scenarios and developing future-thinking skills amongst students inculcates commitment which leads to innovation and action strategies for change (Cebrián & Junyent, 2015). Additional support comes from Luederitz et al. (2016) who identify the need for both normative and anticipatory competences in sustainability interventions.

7.4 Findings from the Empirical Analysis: Outcomes

The two outcomes that were evaluated were socio-ecological integrity as well as intra- and intergenerational equity. The former is related to the integration of both social and ecological systems (Fluker, 2010). The latter considers the issue of justice both between current and future generations (Solow, 1974). Intra-generational equity refers to issues of fairness and justice within society in the current generation (Mattioli, 2013). Neither of these outcomes was achieved during the development of the model. According to a student evaluator: *“Sustainability also does not seem to be mainstream here, yet. Therefore, not many people think about future generations and the impact that past and present generations have or are creating. This is a difficult topic that can and should be explored further”* (SSE).

In terms of a metric for measuring these outcomes, it might be argued that carbon footprinting was a useful proxy, as it illustrated in a numeric term to what extent the campus was able to reduce its GHG emissions, as a way of reducing the university's negative impact on the environment, for current and future generations. The data from the carbon footprints collated during the course of the study shows limited outcomes in this regard.

As shown in Figure 21, during the first year that the footprint was collated, the campus emitted an estimated 87 777 t CO₂-e. This shrank marginally (by 2,8%) to 85 299 t CO₂-e the following year and then grew again to 87 255 t CO₂-e (2,3%). It had been expected that increased awareness that the campus was monitoring its Carbon Footprint would lead to a more significant reduction. Although the reduction achieved was relatively small, it has to be contrasted with a slight (1%) increase in student numbers. This leads to the following observation: that monitoring of Greenhouse Gases does not necessarily lead to a reduction in emissions.

There is some support for this in the literature. For example, Eichhorst et al. (2017) argue that

emission inventory and monitoring is the first step towards understanding the source of emissions, providing a foundation for action. However, this is not enough; an a multi-dimensional strategy, with clear transparency is required to provide the basis for an action plan (Eichhorst, Sun, Bongardt, & Li, 2017). This caveat was clearly intended in Butler’s model. Although he argued that pressures and mechanisms for Green IS would lead to its adoption and ultimately lower GHG emissions he also noted other factors would be necessary. He posited that *“active social involvement may provide the key to success in ensuring that organizations leverage every opportunity to reduce the effects of climate change, particularly through the adoption, implementation and use of Green IS”* (Butler, 2012, p. 403). The next section will examine data relating to the processes developed during the instantiation of the model.

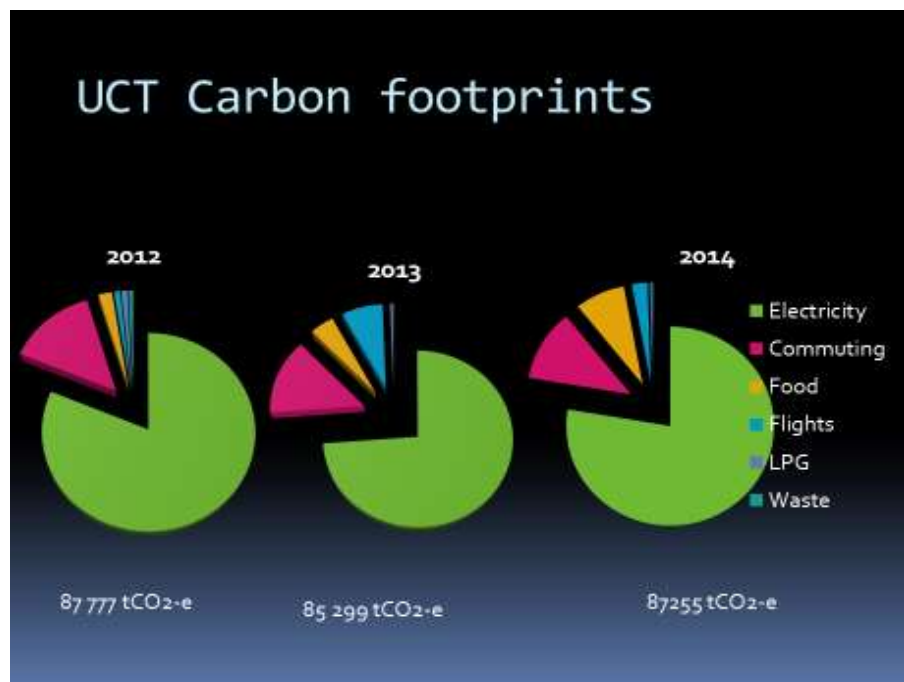


Figure 21: Illustration of UCT's carbon footprints over time.

7.5 Findings from the Empirical Analysis: Processes

It will be recalled from a previous chapter that twin processes were at play in the model development, both leading to outcomes. They were derived from the Green IS literature (Butler, 2011), as well as the Change Management literature of Theory U (Scharmer & Kauefer, 2013). During the summative evaluation, assessors were asked to give a rating to elements of the model in

practice, as they had experienced it, which is illustrated in Figure 22. The processes included a sequence of actions, sound methodology, collaboration, as well as reflexivity and learning.

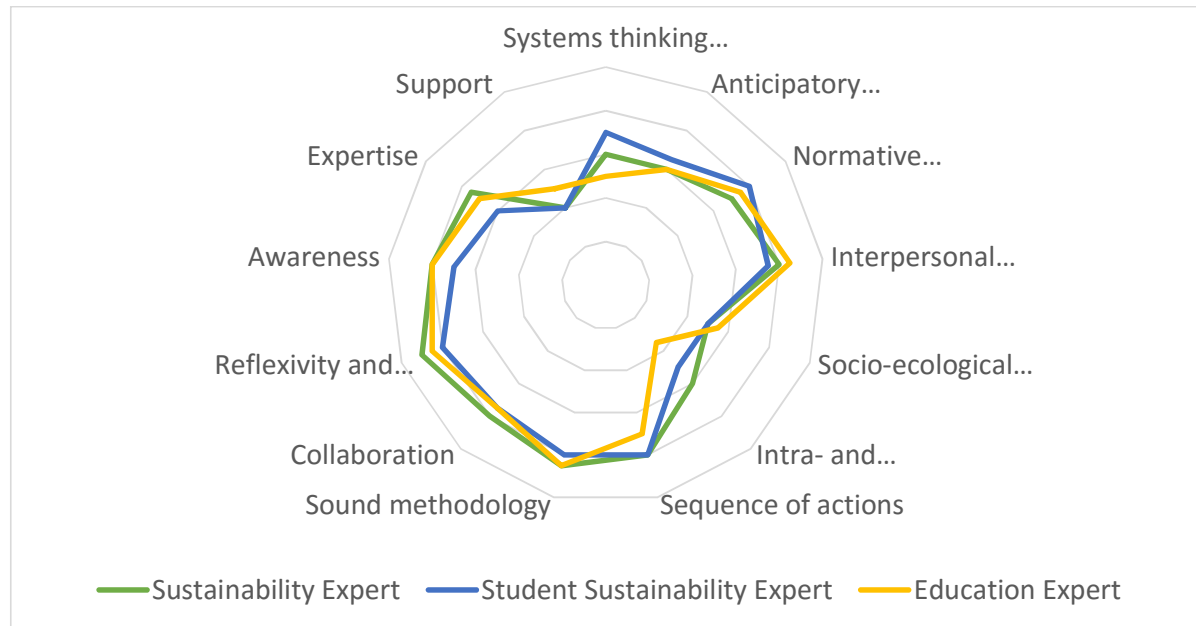


Figure 22: Radial diagram to illustrate scoring of criteria during summative evaluation.

The sequence of actions referred to a logical chain of activities in the learning and teaching process. As can be seen in Figure 22, both the sustainability expert and student sustainability expert rated this highly (8/10).

The student evaluator noted: *“This is done well ... The students are given clearly defined tasks, and the process and outcomes are also discussed (they also have access to previous years’ carbon footprint reports). They are provided enough material through the lecturers and guest lecturers, and then they can explore their topics further. They are also required to think about the roles they play in the group and ensure that there is collaboration and good communication. Furthermore, they are asked to reflect on their experiences, which enhances their learning”* (SSE).

The construct *Sound Methodology* was defined in the summative questionnaire as “a structured approach, including monitoring and evaluation”. There is qualitative data, which suggest the importance of sound methodology as this education evaluator noted the importance of structuring various elements of the course in a logical way, to enable students to make sense of their experiences.

“There was a good attempt in making sure that the students are exposed to the problem, talk to people and then halfway through, introduce the concept of reflection. It was deliberately put there so

that when they came to reflection they had meat to engage with, from their team experiences and talking to people. Then they got theories to help them interpret that and the opportunity to change some of their practises” (EE2). However, the elements of monitoring and evaluation were not as effective as they might have been. The sustainability expert had this critique: At a university level, little is done in terms of M&E (Monitoring and Evaluation) of the carbon footprint trends or setting of goals or targets for continual improvement or mitigation of carbon emissions. Attempts to streamline the reporting process and methodology, including data collection, have not been well supported by the university. Progress towards this goal has not been steady or consistent” (SE).”

The literature also notes a lack of consistency in terms of evaluation of sustainability education initiatives. For example, Stough et al. (2018) argue that different approaches to assessment of sustainability initiatives in Higher Education can affect the results and there is a need to standardise approaches in order to achieve validity.

Another process construct assessed by the evaluators was *Collaboration*, which it will be remembered, was a key skill required of IS graduates in order to collaborate with other professionals when entering the workplace (Topi et al., 2010). This construct required interpersonal skills in order to facilitate collaborative work (Wiek et al., 2011). This construct was rated highly (7.5/10) by evaluators. The student evaluator noted that collaboration had been achieved between students and also with the Green Campus Initiative (GCI) and university staff in the Properties and Services (P&S) division although greater collaboration could be achieved. She said: *“This is done well, as the students have the opportunity to engage with guest lecturers, UCT P&S, GCI and others if need be. I understand that it can be difficult for students to engage with P&S, given that they are full-time operational staff, and they are not based on campus. I am also aware that the response rate can be slow, however, if possible the IS course conveners could possibly work out an arrangement with them, so that information is obtained more easily. Students can also be encouraged to seek out other staff members that are involved in sustainability initiatives” (SSE).*

This need to extend the range of collaborative partners has resonance within the literature. For example, Curry and Donnellan (2012), advocate the sharing of sustainability information among a broad range of regional stakeholders including public administrators, policymakers, politicians, corporations, citizens, and regulators.

Reflection and Learning were described in the summative questionnaire as “continuous analysis of actions as well as iterative learning”. An apt definition came from a student: *“Reflection constitutes the ability to uncover and make explicit to oneself what one has planned, observed, or achieved in practice. Applying this to a group is more of a challenge than applying it to an individual, but it is certainly more interesting because of the colourful personalities that make up a group and the group dynamics that develop and evolve over the lifetime of the group”* (ST3A).

Meanwhile, an education evaluator remarked that the course enabled students to build intelligence on different levels through reflection and learning. She wrote: *“A wide range of elements contributed towards empowering students, not only to cope with the course material, but also to build their emotional intelligence. According to Jordi, it is vital to integrate a range of cognitive and non-conceptual elements that make up experience (Jordi, 2011). Creating coherence in the complex environment of a capstone course did just that and developed mature and well-rounded, reflexive practitioners. At the hand of carefully chosen readings, the students started to appreciate the value of questioning their own assumptions ...”* (EE1).

This is confirmed in the literature, for example in Goleman’s treatise on Ecological Intelligence, which he defines as follows: *“Ecological refers to an understanding of organisms and their ecosystems, and intelligence connotes the capacity to learn from experience and deal effectively with our environment”* (Goleman, 2009, p. 43).

7.6 Findings from the Empirical Analysis: Inputs

During the summative evaluation, evaluators were asked to critique three criteria: awareness, expertise and support. These will now be addressed in turn.

In terms of *Awareness*, as an input, there was a paucity of understanding of Green IS issues or sustainability in general. One education expert observed: *“For the most part, it was the first time that students had their first exposure to Sustainability. We had a huge opportunity of making that impact because we were starting from zero. The lecturers opened their eyes. You can see this from the evaluation feedback. They became more aware”* (EE2).

The limitations of creating awareness in the students during a short course were, however, noted as this comment attests: *“The carbon footprint methodology and scope do cover a range of sustainability topics. However, students only discover one aspect in more detail ... sustainability is a very broad topic, with many applications. Not all of them can be covered adequately in a one-*

semester course. Sustainability awareness would be further enhanced if the students had to put into practice their recommendations – this is of course beyond the scope of their project” (SSE).

Expertise concerns the expert knowledge provided by recognised professionals, according to the summative questionnaire. An education expert observed that *“Coaching and mentoring from the ERC expert and the UCT sustainability consultant ... dedicated invaluable resources towards collating results from the student teams’ projects in the sustainability reports. ... The input of Green IT and Green IS theories and being part of the International Sustainable Campus Network (ISCN) helped to instil a passion to develop skills for future leaders” (EE1).*

However, the Student Sustainability Expert thought there was a deficit of expertise with a contrary viewpoint as follows: *“I think more sustainability experts can be utilised. As far as I know only two guest lecturers presented on sustainability and the carbon footprint reports” (SSE).*

Given the time constraints, it was not feasible to include more than two guest lecturers in the course schedule, but the concern is noted, and perhaps a more creative solution could have been found, for example, by including experts as opposed to lecturers during tutorial sessions.

Support related to the structural, financial and non-financial resources from the university. Although the research and teaching Green IS project garnered several small financial grants from the university, providing pedagogical support, this criterion, overall was identified as a deficit. This critique was provided by an evaluator: *“University administration only contributes some financial support of the Independent consultant ... Attempts to secure software resources failed. Response to requests for data, interviews vary from person to person in the administration, but are generally lacking, resulting in research not being undertaken, making more forward progress (difficult)” (SE).*

The decision not to continue the Green IS project (in 2017) was also seen as a problem, as the university failed to “institutionalise” Green IS (EE2). In addition, the lack of support from students for monitoring the campus carbon footprint was identified as a drawback in a later UCT carbon footprint report. *“It is important for the university, as a learning and research institution, to continue to involve the IS students in the carbon footprint measurement process as part of the curriculum. This can deliver a range of enhanced learning outcomes already recognised by the Higher Education Learning and Teaching Association and the International Sustainable Campus Network (ISCN). Amongst these are preparedness for the challenges of climate change, developing literacy and*

understanding of sustainability, and a capacity for responsible local and global citizenship'' (Rippon, 2017, p. 5).

7.7 Summary

This penultimate chapter set out to discuss the implications of the summative evaluation of the Green U, which gave the author the opportunity to reflect on some of the issues arising out of the final evaluation, in line with the requirements for DSR. Initially, the chapter situated the research within the context of sustainability history at the University of Cape Town, as an important way of grounding the discussion in the empirical reality. Next, there was an opportunity to examine various aspects of the evaluation of the model in practice and linking the findings to prior research as a way of confirming observations. The chapter followed the sequence adopted by prior sustainability researchers, namely starting with outputs, and then proceeding to examine the outcomes, processes and inputs.

An important finding from the outputs was that normative competence emerged as the strongest skill in the suite of sustainability competences developed in the students. This was followed by interpersonal, anticipatory and systems thinking competence. Linkages between interpersonal and key sustainability skills were highlighted as were the interconnectedness of normative and anticipatory competences. In terms of the outcomes, two constructs were discussed. They were socio-ecological integrity as well as intra- and intergenerational equity. These constructs were found to be weakly exhibited, according to the evaluators. Process issues were also discussed, with evaluators giving relatively high scores to constructs that included a sequence of actions, sound methodology, collaboration, and reflexivity and learning. Finally, a range of inputs was discussed, including awareness, expertise and support. Although awareness and expertise were identified during the evaluation, a shortage of institutional support was noted by evaluators.

Having discussed some of the main issues arising from the final evaluation of the Green U, the stage has now been set for the final chapter in this thesis, where conclusions will be drawn, as well as opportunities for further research explored.

Chapter Eight – Conclusions

8.1 Introduction

This thesis followed a Design Science Research approach to design an IS artefact that addresses a significant problem relevant to the IS academic community. Through a rigorous approach the Green U was designed, evaluated and discussed. The final step of the DSR approach requires communicating the findings to a wide audience, and the goal of this chapter is to draw all of the threads together into a coherent whole.

It will be recalled that the author had identified a clear problem: the discipline of IS had failed to incorporate sustainability in the form of Green IS into its undergraduate curriculum. Since this issue was of global scale and not easy to solve, it was a relevant and persisting problem. In addition, it could be argued that a solution to this problem would be of value to current and future generations. This chapter revisits the research problem and shows how the study has met the DSR principles as set out earlier by Hevner et al. (2004). Contributions to both theory and practice are outlined throughout this chapter and limitations are acknowledged, leading to fertile avenues for further research.

8.2 Denouement

In this thesis, the author placed the context for this research at the intersection of sustainability, IS and education. This section will now describe how the chapters framed the research problem and the denouement, that is, the pathway that was followed to finding a solution.

The aim of this study was to prescribe a model to incorporate Green IS into the curriculum of undergraduate students. Secondary objectives in support of the development of the artefact were (1) to investigate pre-existing Green IS theories; (2) to conduct a literature review in the area of sustainability in Higher Education; and (3) to evaluate key constructs and competences arising from the model.

The research objectives were aligned with the call for the discipline of IS to make the world better (Walsham, 2012) and to address global challenges, such as the seventh Millennium Development Goal of ensuring an interconnectedness of social and environmental concerns (Hajer et al., 2015; Waage & Yap, 2015).

Chapter two elaborated the problem by uncovering the growth of Green IS over the decade since its inception. The problem of incorporating Green IS was shown to be a complex one, as the field had evolved through various stages. Initially the theme of Green IS was purely conceptual (Malhotra et al., 2013). This was problematic for incorporation into the curriculum, as it had not been empirically validated. The next stage of Green IS focused on analysis of previous research (Malhotra et al., 2013). Although this was more developed than the initial stage, for students, it was problematic for application as its impact and effectiveness had not yet been elucidated. The final two phases, namely the design and impact, were more helpful, however, the problem was that very few senior scholars in IS had published journal articles incorporating the design and impacts of Green IS (Gholami et al., 2016). This was, nevertheless, an opportunity as it represented an important research gap to be filled. This literature review provided the foundation on which to build a Design Science Research artefact, giving a solid theoretical basis in the search for a kernel theory.

The problem of curriculum was addressed in chapter three, which also took the form of a literature review, albeit in this case the studies in question related to sustainability as taught in higher education. Here the problem was elaborated further. The question of how to address student engagement was addressed, (Albanese & Mitchell, 1993), as well as the need for deep learning, rather than surface learning (Marton & Säljö, 1976). The conclusion drawn was that student engagement and deep learning for sustainability was best achieved through both a problem and a project (Brundiers & Wiek, 2013). A further challenge was to decide on which competences to develop. It was clear that pure technical skills would be insufficient, and a search was conducted for appropriate competences to aid students during the challenges of project management. These skills were identified in prior literature as systems thinking, anticipatory, normative and interpersonal competence (Wiek et al, 2015). However, how to achieve these competences added another layer of complexity to the problem. Ultimately, this literature review led to the change management research (Batra et al., 2016), as the students were expected to undergo personal change during the course of the semester. This led the researcher to Theory U (Scharmer, 2009). However, its application to curriculum change had been limited which was identified as an opportunity to address, rather than a problem.

In chapters two and three, kernel theories were identified as useful lenses for this study. The first is a theory of Green IS (Butler, 2011), which posits that institutional change can be explained by regulative, normative and cultural-cognitive influences, leading to Green IS- enabled activities and

sustainability outcomes. This lens has deep roots in institutional theory, drawing from the seminal work of DiMaggio and Powell (1983). A second lens was identified in the change management literature and is known as Theory U (Scharmer, 2009). Based on action research, this theoretical framework offers a pathway that also leads to outcomes. The pathway begins with co-sensing, moves to co-presencing and ultimately leads to co-creating. This was mapped onto the pre-existing three-step process of agile software development, which starts with following, reaches a turning point with detachment and leads to fluency (Cockburn, 2002).

It is worth noting that research has been done to link sustainability to curricula elsewhere in the world (Lozano et al., 2014), although limited work has been done in this respect in Africa (Scott, McGibbon, & Mwalemba, 2012). This context adds another layer of interest to the study, as Africa will bear the brunt of the ravages of climate change and unique local adaptations will be required (Strydom & King, 2000). Consequently, education to equip students to prepare for the challenges of climate change, with sustainability literacy as well as local and global citizenship (Rippon, 2017).

The role of educators as facilitators of conceptual change is documented in the literature, including the need to equip students to become sustainability change agents able to deal with complexity and soft (human) as well as hard (technical) issues (Lozano et al., 2014). The infusion of sustainability concepts across the academy has been widely addressed (Jones et al., 2010), with responses from fields as disparate as science, geography, nursing, law, dance, drama, music, engineering, theology, and economics with the notable absence of IS.

Chapter four considered various paradigms in a bid to ascertain the most suitable for addressing the research problem. Positivism, Interpretivism and Critical Discourse were rejected as contender paradigms as there was a poor fit between them and the research problem. In contrast, Design Science Research (DSR) was considered as the most appropriate paradigm, as it enabled the researcher to study a real-world problem in situ, drawing on the unique blend of technological and social frameworks offered by the IS research community. In addition, the desirability of creating an artefact during the course of the study would enable the research to fit with the Green IS tradition dedicated to design and impact. Hence the methodology was positioned directly within the DSR paradigm. To ensure rigour, steps were elaborated, including identifying the problem, the design search process, artefact development, evaluation and communication of the research findings.

Chapter five spelt out the steps taken during the design development phases over multiple iterations when, at an early stage of development, problems with the model were identified. As the model was repeatedly re-evaluated it enabled it to be simplified or extended as required, using the aforementioned kernel theories which linked to create joint outcomes.

Chapter six was logically the next step as this provided a summative evaluation. A small team of expert evaluators was enlisted to provide a critique of the various elements of the model, including the outputs, outcomes, processes and inputs. Analyses of these evaluations (completed by two education experts, one sustainability expert and a student sustainability expert) provided rich findings of the linkages between key elements.

Lastly, in chapter seven, there was an opportunity to discuss the implications of the empirical analysis. Key findings showed that the problem of integrating Green IS into the curriculum had yielded a number of insights regarding the development of sustainability competences. The most significant of these was interpersonal competence, a soft skill, which was seen as key to developing collaborative partnerships between students in addressing sustainability challenges.

Ultimately, these chapters enabled the research problem to be extensively investigated, complete with proposed solutions to the problem of alleviating the lack of Green IS education in undergraduate IS courses. At this juncture, it is appropriate to revisit the research objectives, with a view to assessing to what extent they have been addressed.

8.3 Revisiting the Research Objectives

It will be recalled that the primary objective of this study was to develop a prescriptive model for integrating sustainability into the IS curriculum. This was achieved through the design search process elaborated in chapter five. The model included two key processes, namely the Green IS technical process and simultaneously a change management process based on Theory U, with high-level constructs that included downloading, presencing and co-creation. This collaborative process was demonstrated in practice and ultimately evaluated. A range of competences was envisaged as part of the model, and these included interpersonal, normative, anticipatory, and systems thinking competences. As the model was based on kernel theories derived from the literature in conjunction with data from the evaluations, it can be concluded that it presents a viable option for integrating both the hard, technical skills and the soft, interpersonal, anticipatory, normative and systems thinking competences.

The perception of students was assessed at six points during the development of this model, and their perspectives helped the model evolve via each iteration of the design cycle. Finally, evaluations were conducted at the completion of the six-year project, which allowed the final model in practice to be assessed. This showed the practical feasibility of the model.

It will be recalled that there were three secondary research objectives in support of the primary objective. First, the goal was to investigate the phenomenon of Green IS. This was effected via a systematic literature review, which critically assessed scholarly work published in the top journals over a 10-year period. Second, the author set out to conduct another literature review in the field of sustainability education. This was done in order to identify a potential theory to undergird the development of the artifact. Third, the objective was to evaluate key constructs including relevant sustainability competences. This was achieved via summative evaluations conducted by a team of expert evaluators, and their responses analysed via Computer Assisted Qualitative Data Analysis Software (CAQDAS).

Although it has been argued that the research objectives have been achieved, the next section of this chapter argues how the study has achieved the requirements for an effective Design Science Research project.

8.4 Revisiting the Design Science Principles

An important aspect of this thesis concerns the type of discourse to which it contributes, as well as the research community at which it is aimed. DSR has recently staked its claim as a legitimate IS research paradigm (Gregor & Hevner, 2013), and it is at this domain that the contribution to knowledge is aimed. As will be recalled, a publication schema for such a study should include the goals that are required of an artefact, a design theory relating to the artefact, the specific DSR approach, the artefact description, evaluation, discussion and conclusions. In order to follow a rigorous scientific method there are seven requirements for DSR (Hevner et al., 2004). These are listed as follows:

1. The *design of an artefact* as a research output, addressing an important problem.
2. The problem should be *relevant* to the academic community.
3. The design requires *evaluation* on a range of criteria.
4. The researcher needs to identify clear *contributions* to knowledge and practice.

5. The research should be *rigorous* – with rigour applied to both the creation of the artefact and its evaluation.
6. An iterative *search process* for the design should be demonstrated.
7. The research findings should be *communicated* to a wide audience.

8.4.1 Design as an Artefact

In terms of the early proponents of DSR, the research output needs to be a designed artefact that addresses an important problem (Hevner et al., 2004). Therefore, the main deliverable from this thesis was the design of a prescriptive model, namely the Green U Theory. Although the model draws from kernel theories, it can be considered an innovation in terms of DSR since it exapts constructs from other areas into a new framework (Gregor & Hevner, 2013). The fact that the artefact emerged during a six-year curriculum innovation also makes it a good fit with DSR, as the search for the design was iterative over many cycles as shown in Figure 25.

8.4.2 Problem Relevance

The problem of sustainability has been argued in the literature as one of the greatest challenges of our time (Giddens, 2009; Hansen, 2005) and yet the discipline of IS has been reticent to embrace this challenge (Becker et al., 2015; Gholami, Watson, Molla, et al., 2016; Seidel et al., 2017). The problem of integrating Green IS into the curriculum is at the crux of this issue since other disciplines have already embraced this challenge (Sterling & Huckle, 2014). As can be seen in Figure 23, the relevance cycles intersected with the design and rigour cycles.

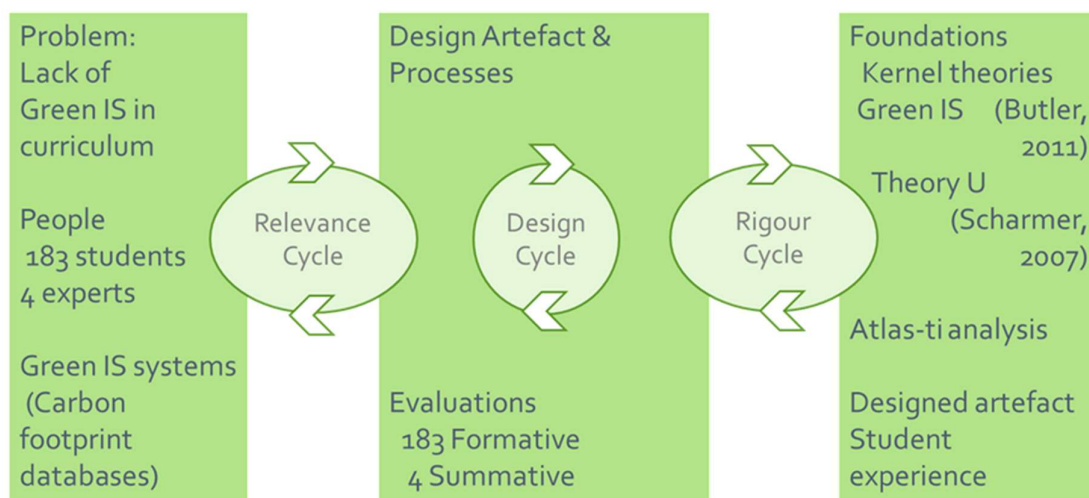


Figure 23: Design of artefact showing three cycles based on Hevner (2007).

The issue of relevance was endorsed by Ross in this commentary: *“Fourth, the course potentially equips the University to identify the action points at which a successful footprint reduction strategy would optimally be targeted. Climate change arising from carbon emissions is among the most important, but also the most practically daunting, problems of the current century. It will remain so throughout the lives of the students. The course thus perfectly exemplifies socially responsive teaching and learning”* (Ross, 2015).

8.4.3 Design Evaluation

An evaluation was conducted at the end of each of the six iterations of the design development. Archival evidence as well as student reflective essays were analysed through content analysis and coding of the empirical data which made use of the data analysis software tool, ATLAS.ti. The design underwent six formative evaluations (with a total of 183 evaluators) as well as one summative evaluation event (with four expert evaluators). The outcomes, outputs, processes and inputs were assessed by the evaluators, including a range of built competences. These included interpersonal, anticipatory, normative and systems thinking competences.

8.4.4 Contributions

Contributions were made to both theory and practice. The most significant contribution to new knowledge was the development of a prescriptive model, the Green U Theory, which was derived after a rigorous design process. This deepened knowledge of the Green IS domain as it adapted a simplified version of Butler’s (2011) Green IS model into the Higher Education context. In addition, it extended knowledge within the Sustainability in Higher Education context, by providing prescriptive theory on how to include Theory U in the curriculum in order to develop a range of sustainability competences. The implications of this new knowledge will now be discussed.

It will be recalled from chapter two that scholars have categorised Green IS research according to four phases: Conceptualisation, Analysis, Design and Impact (Gholami et al., 2016). The prescriptive model of the Green U Theory was not limited to the first two stages of Green IS research, namely Conceptualisation and Analysis. This study may rather be included in the third phase, namely the Design of Green IS, as envisaged by Malhotra et al. (2013).

It also represents a knowledge contribution which is *transformational*, in that it used design to trigger change (Ceschin, 2014). This resonates with the literature which describes two types of knowledge contribution within the broad realm of sustainability science – *descriptive-analytical* and

transformational (Wiek et al., 2012). *“The first [descriptive-analytical] is concerned with analyzing problems in coupled human–environment systems, whereas the second [transformational] conducts research on practical solutions to those problems”* (Wiek et al., 2012, p. 5). Since the study went beyond analysis and searched for a practical solution to the problem of the shortage of Green IS in undergraduate courses, it can be argued that the knowledge contribution of this study was transformational, as opposed to descriptive-analytical. There was also evidence for the use of DSR to trigger change. For example, during the summative evaluation, an evaluator noted that student behaviour was transformed – following reflection on their habits, with implications for the wider campus community: *“They had to investigate a specific problem on campus and make recommendations. In many cases they were implicated. For example, waste – they threw away every day. Printing, they do every day. They started to reflect on their own habits and were able to make recommendations”* (EE2).

In addition, a third form of knowledge contribution has been identified in the sustainability science domain described as *process-oriented* (Luederitz et al., 2016; Wittmayer & Schöpke, 2014). It is argued that the Green U Theory, in Figure 16, is also a good fit for this category as twin processes were employed. The top part of the model illustrated the hard technical skills driven by regulative and financial influences, leading to Green IS enabled activities and ultimately outcomes. The bottom part of the model, in the U-shape, started with a range of drivers, including normative, cultural-cognitive and collaborative influences. These helped to shape the soft skills developed during the U process. At the top of the U was the co-initiation of teams, leading to the key element of presencing, and ultimately co-creating in the final upward leg of the “U”.

The two processes (descriptive-analytical and transformational), in tandem, developed both technical or hard skills, such as carbon footprint calculations, as well as the soft skills of anticipatory, interpersonal, normative and system thinking competences. The skills that were found to have the highest ratings from evaluators were reflexivity and learning. As one evaluator observed: *“The students started to appreciate the value of questioning their own assumptions, become self-aware, transcending towards self-leadership and then moving forward to appreciate collaboration with compassion, working collectively and concurrently gaining team leadership for all”* (EE1).

This process-oriented knowledge contribution has resonance in the literature as a form of actionable knowledge with *“evidence-supported guidance for practical application that has been tested in successful efforts to solving (or at least mitigating) a sustainability problem within the defined*

experimental setting” (Luederitz et al., 2016). In particular, process-oriented knowledge includes studies conducted by researchers who adopt the roles of “*reflective scientist, self-reflexive scientist and process facilitator*” (Wittmayer & Schöpke, 2014, p. 483). This innovation provides evidence-supported prescriptive theory with a practical application that had been created to help solve a sustainability problem through creating anticipatory and normative knowledge (Frantzeskaki & Tefrati, 2016)

In addition to this, readers may wish to consider the practical contributions. There is nothing as practical as a good theory according to Kurt Lewin (McCain, 2015) and so it was that the research project was able to provide value to practitioners, in particular academics within IS, but also to the broader field of Sustainability in Higher Education. There are two arguments to be made here. The first concerns the value of the model in enabling students to have an engaged and deep learning experience with Green IS. The second addresses the potential of the model for exaptation into other nascent fields.

Firstly, a search was done via the literature to find the most appropriate pedagogy for introducing students to Green IS, and the strategy of Problem- and Project-based Learning was found to be the most appropriate. The Green U model, which emerged over multiple design cycles, therefore, presents educators with a visual guide for incorporating both technical and soft skills into their Green IS programmes. The model, while prescriptive, was also sufficiently robust to enable exaptation. It was deliberately left uncluttered by the specifics of outcomes (and outputs), to enable educators to adapt the model for their own use. It is recommended that educators start with the end in mind. They need to consider what outputs (such as anticipatory, normative, interpersonal and systems thinking competences) will be required and keep this in mind when designing coursework and assessments.

A second argument is to be made about the generalisability of the model. Although it arose out of the Green IS problem space, it could be exapted to other nascent themes in IS. Since the discipline is constantly evolving, with students needing to be educated in both technical and soft skills, the dual-process model could well be applied in other emergent themes. The value of simultaneously learning technical skills and the deeply reflective “U” process will enable students to not only co-initiate, but also co-create innovations. The pedagogical value of the Green U Theory thus underlines the practical contribution of the model to Higher Education, and in particular to the field of IS.

8.4.5 Research Rigour

Arguments to support claims for rigour were made throughout the thesis. This began with the systematic literature review of Green IS as a thorough and comprehensive process. Rigour was also applied to the design search phase, when a systematic procedure was followed in line with current Design Science Research principles. In the interests of rigour, this thesis followed the method described by Gregor and Hevner (2013) which is supported by other authors (Peppers, Tuunanen, Rothenberger, & Chatterjee, 2007). The sequence included identifying the problem; defining the solution objectives; design and development; demonstration; evaluation and communication. At the evaluation phase, the questionnaire was sent to an external researcher for validation and a pilot study was conducted. The summative evaluation was also rigorously completed, with documents collated and coded in Atlas.ti thereby enabling future researchers to conduct similar studies.

8.4.6 Design as a Search Process

The process for developing the Green U model was the result of a six-year pursuit of an appropriate model through a process of refining elements, which were not useful and incorporating new elements. A reflective and reflexive approach was conducted throughout via cycles of relevance, design and rigour, as illustrated in Figure 24.

8.4.7 Communication of Research

This thesis is one way that the research has been communicated, but during the course of the project a total of 10 peer-reviewed scholarly outputs were communicated to the research community which are documented in Appendix A, hence this thesis is the 11th output.

In conclusion, an examination of the study reveals that the research project satisfies each element of the guidelines for effective DSR. The limitations for the study will now be addressed.

8.5 Limitations

In chapter one, it will be recalled; the scope of the study was delimited. In that chapter, it was acknowledged that the focus of the study was to be restricted for several practical reasons to ensure that the doctoral project remained focused.

8.5.1 Methodology Selection

The research project entailed using DSR as the paradigm. There are some clear limitations in this selection, as other useful methodological tools were excluded. For example, a positivist approach

may have been employed to operationalize the model and test each construct in it. This was not done as it was beyond the scope of the study to apply two different paradigms with incommensurable underlying assumptions. It needs to be considered, however, that the impact of not testing each construct may have led to refinements, and greater validity of the model.

8.5.2 Implementation Issues

Although many researchers working in the Sustainability for Higher Education domain call for multi-disciplinary or interdisciplinary approaches, this broad scope was not adopted during the implementation of the research study. Instead, a single case was the focus of the investigation. This is therefore a limitation. Indeed, the fact that the carbon footprint was undertaken by only one faculty at the university illustrates the limited scope of the project, a conclusion which was also reached by the evaluators, who noted the limited impact as opposed to interventions across faculties which could have had a greater impact. In addition, only Face-to-face lecture styles were adopted. This means that opportunities for online learning, potentially with a global classroom, were not utilized, in spite of online or blended programmes increasingly fulfilling the needs of learners who wish to study when and where they want to. The idea of the global classroom has been facilitated by the current revolution in online learning platforms with an *“intense, personal learning relationship among a global, multilocal community of learners and a world-class faculty by combining live-streamed classroom sessions and mini-lectures with highly interactive small-group practice sessions. Social media-supported conversation spaces would continue the classroom dialogue between sessions”* (Scharmer & Kaeufer, p.243).

8.5.3 Lifelong Learning not Addressed

Although, it was hoped that students who were taught anticipatory competence would develop a future-oriented mode of thinking, including lifelong learning, this was not directly addressed. At each iteration during the design search, as documented in chapter five, attempts were made to evaluate the model in progress. This led to refinements and adaptations. However, at the end of the process, although four evaluators gave candid assessments of the model in practice, the model itself could not be implemented in practice due to external factors. Curtailment of the project at the end of the six-year intervention meant that this possibility was excluded from the research.

8.5.4 Focus Merely on Green IS

The research focused, by design, solely on the incorporation of Green IS into the curriculum, using Carbon Footprinting as a proxy for sustainability. A broader focus on other issues relating to

sustainability, for example, biodiversity loss and conservation of endangered species, were excluded from the project.

Having examined some of the limitations of the study, it is appropriate to map out some fruitful avenues for future researchers, as the limitations hold within them the seeds of new research endeavours.

8.6 Directions for Future research

Arising directly from the limitations identified in the previous section, the author now proposes suggestions for future research.

8.6.1 Extend the Range of Methodologies

While it was logical to argue that a “how” question was best answered by DSR, it would be useful for future researchers to explore other paradigms involving Green IS and the curriculum, as this would enrich the understanding of the topic. It must be borne in mind that none of the available approaches were uniquely suited to incorporating Green IS into coursework as an action. However, future researchers may build and extend this study. For example, *critical discourse analysis* would yield useful insights into analysing what a campus purports to do about sustainability (for example, in charters) and what, in fact, it does. A useful Research Question here might be: Why is an institution of Higher Education slow to apply sustainability across all its operations? *Positivism* could be used to test each element of the Green U model, as a way of validating the constructs. *Interpretivism* would be instructive in doing in-depth explorations of how student identity is shaped by, green values, for example. However, none of these methodologies address the design, incorporation, evaluation and communication of an artefact, which was the goal of this study.

8.6.2 Implementation of Multiple Courses

A limitation identified in the previous section was that the research focused on a single course for the intervention. This runs counter to best practice in the Sustainability in Higher Education literature. Viegas et al., (2016) reported that interdisciplinarity (co-operation between disciplines) and transdisciplinarity (transcending disciplinary boundaries) is useful in bringing different stakeholders together to solve intractable problems. To have a greater impact, courses across disciplinary boundaries, would be useful in which to test interventions, as opposed to being restricted to the IS discipline.

8.6.3 Lifelong Learning

A limitation described in the previous section was that although sustainability issues were ongoing, no attempt was made in the current study to keep track of the student evaluators after leaving university. Although the time frame for this may be outside the ambit of some researchers, it would be valuable for longitudinal studies to investigate if students who have been educated in sustainability still practice sustainability behaviour and integrate lifelong learning into their lives. Additional value could be added via later evaluations, for example, once graduates are in the workplace, to see whether their competences learned at university were maintained and extended. For example, to survey whether computer scientists in the workplace (alumni of the Green IS programmes), maintain their environmentally-aware normative and anticipatory competences.

8.6.4 Focus Beyond Green IS

Although this research study explored the incorporation of Green IS into the curriculum, a range of other sustainability topics could be included in courses from other disciplines, as well as more comprehensive sustainability programmes within IS, for example citizen science projects by students to monitor environmental changes. The testing of the development of ecological intelligence as propounded by Goleman (2009) could also be a valuable way of expanding the Green U across the entire campus of a university, and not limit it to one IS programme. In addition, the Green U could be applied to the entire campus in order to help students and staff to co-create strategies for water management at home and at university. This extension of the Green U model means that it could be exapted into other environmental issues. In addition, the Green U could be exapted into other IS themes which are nascent, for example to build both technical and social skills in new and evolving IS research themes.

8.7 Summary

The purpose of this thesis was to provide a coherent response to the relevant and persisting problem of the lack of Green IS teaching and learning within the domain of Higher Education. It was deemed a relevant problem, since it aligned with the greater call to produce graduates who are sensitive to the needs of environmental sustainability, an issue that has been on the global agenda for thirty years and has yielded no straightforward solutions. The major contribution of the study was thus the creation of the Green U model for integrating sustainability into the IS curriculum.

This thesis set out to demonstrate a command of the literature of both Green IS as well as sustainability in Higher Education. This was done through searches of the extant literature on both

topics. In particular, the author set out to show an understanding of the theoretical frameworks, which underpinned the development of the DSR artefact. This was done via engaging with the foundations of the kernel theories.

To achieve internal consistency in the thesis, two kernel theories were identified as theoretical frameworks that provided guidance and structure to the investigation. They were Butler's (2011) Green IS theory as well as Scharmer's (2009) Theory U.

Furthermore, the author applied the approach in a systematic manner. Since this study started with a problem, namely how to incorporate Green IS into the curriculum, DSR was selected as the methodological approach due to its ability to enable both a focus on problem solving as well as theory development. The guidelines for DSR were rigorously followed, including six iterations to enable structured reflection, evaluation and development of the artefact - the primary deliverable of this thesis. In addition, the research contributes to the discipline of IS via expanding the knowledge base for designing and conducting Green IS interventions within the domain of Higher Education.

A further important consideration is that communicative competence was demonstrated, both via listing 11 peer-reviewed scholarly outputs related to Green IS as well as the compilation of this thesis to a standard worthy of external examination. In addition, an understanding of ethical issues was demonstrated, during the trajectory of the author from student to scholar. Finally, the author hopes that this study opens up a rich seam of possibilities for IS researchers and encourages future projects that apply, critique, extend, and improve the Green U Model.

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Appendices

Appendix A: Ten Peer-Reviewed Scholarly Outputs related to Green IS

1. Zlobinsky, N., Oldsen-thor Straten, I., & McGibbon, C. (2018, May) *Rain Gain: An IoT solution for rainwater harvesting to address Cape Town's water crisis*. Paper presented at BUIS-Tage Smart Cities / Regions, Oldenburg, Germany.
2. McGibbon, C. & Ophoff, J. (2017, August). *Green Information Systems: Building Competences in Students*. Paper presented at the Americas Conference on Information Systems SIG Green workshop, Innovation: Building a Tradition of Research and Practice, Boston, United States.
3. McGibbon, C. (2017, September). *In search of greener pastures: Integrating sustainability into the South African undergraduate Information Systems curriculum via an examination of the literature*. Paper accepted for presentation at Symposium on Sustainability in University Campuses (SSUC-2017) in Sao Paulo, Brazil.
4. McGibbon, C., Ophoff, J., & Van Belle, J.-P. (2015). Our building is smarter than your building: The use of competitive rivalry to reduce energy consumption and linked carbon footprint. *Knowledge Management & E-Learning: An International Journal*, 6(4), 464-471.
5. McGibbon, C., & Van Belle, J.-P. (2015). Integrating environmental sustainability issues into the curriculum through problem-based and project-based learning: a case study at the University of Cape Town. *Current Opinion in Environmental Sustainability*, 16, 81-88.
6. Kotze, C., Van Belle, J.-P., & McGibbon, C. (2014, September). *Key drivers of Green Information Systems in South African listed companies*. Paper presented at Confluence, The Next Generation Information Technology Summit 5th International Conference, Delhi, India.
7. McGibbon, C., & Van Belle, J.-P. (2013, September). *Integrating Green Information Systems into the Curriculum Using a Carbon Footprinting Case*. Paper presented at the International Conference on Information Management and Evaluation, Sopot, Poland.
8. Scott, E., McGibbon, C., & Mwalemba, G. (2012, June). *Attempts to Embed Green Values in the Information Systems curriculum: a Case Study in a South African Setting*. Paper presented at the European Conference on Information Systems, Barcelona, Spain.
9. McGibbon, C. (2011, July). *Green IT and Green IS: Which is lion and which impala?* Paper presented at the Pacific Asia Conference on Information Systems Doctoral Consortium, Brisbane, Australia.
10. Petzer, C., McGibbon, C., & Brown, I. (2011, October). *Adoption of Green IS in South Africa: an exploratory study*. Paper presented at the South African Institute of Computer Scientists and Information Technologists Conference on Knowledge, Innovation and Leadership in a Diverse, Multidisciplinary Environment, Cape Town, South Africa.

Appendix B: Evaluation instrument



PHD RESEARCH CONDUCTED BY: CAROLYN MCGIBBON

FACULTY OF COMMERCE

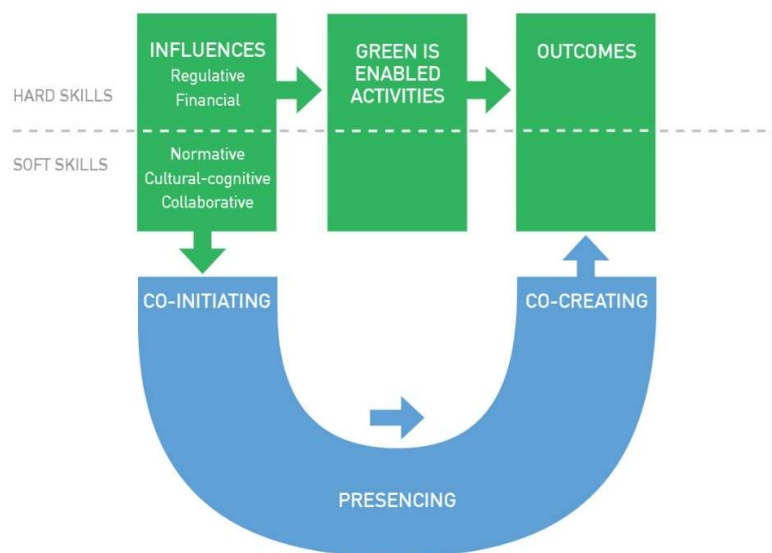
Since 2011 the Department of IS at the University of Cape Town has incorporated Green IS into the curriculum and in the process developed a model for enabling students to monitor the campus carbon footprint. This breaks new ground as sustainability had until then not been part of the IS curriculum.

Prior to the course, 50% of the class indicated that their understanding of sustainability issues was “none or slight”. After the course, 72% of the class reported that their understanding of these issues was “substantial”.

The new model, which is shown below, combines the essence of two existing theories. The green section is based on the Green IS theory propounded by Butler (2011) which starts with a range of influences which impact on Green IS enabled activities, leading to environmental outcomes.

Simultaneously, there is a blue route based on U Theory (Scharmer, 2009). This process begins with co-initiating and leads to presencing, a situation where reflection leads to a change of direction, and ultimately co-creation and ultimately to outcomes.

As can be seen in the model, it involves nurturing both the hard skills of carbon footprint measurement which are driven by regulative and financial influences. In addition, the process has developed the soft skills of co-initiating, collaboration, teamwork, co-creation, and communication. These are driven by normative, cultural-cognitive and collaborative influences, according to Butler (2011).



Model for incorporating Green IS into the curriculum.

At the heart of the process is “presencing” which includes reflection on actions. This dynamic project has won an international Best Case Study award at the World Economic Forum as well as the Higher Education Learning and Teaching Association of Southern Africa excellence award. Your expertise is now required to evaluate the process based on sustainability and educational criteria.

Evaluator name:

Designation:

Capacity building of students

Systems thinking

Systems-thinking competence is the ability to collectively analyse complex systems.

How successful do you think the process is at building systems thinking in students?

Capacity building of students

Anticipatory competence

Anticipatory competence is the ability to visualise the future related to sustainability issues.

How successful do you think the process is at building anticipatory competence in students?

Capacity building of students

Normative competence

This is the ability to collectively assess the unsustainability of current campus operations and make recommendations on how to make UCT more sustainable.

How successful do you think the process is at building normative capacity in students?

Capacity building of students

Interpersonal competence

This is the ability to motivate, enable and facilitate collaborative work among fellow students.

This includes skills in communication, collaboration, leadership and diversity management.

How successful do you think the process is at building interpersonal competence in students?

Outcomes for UCT

Socio-ecological integrity

This involves harmonising the wellbeing of both the campus community and its ecosystem.

How successful do you think the process is in creating socio-ecological integrity on campus?

Outcomes for UCT

Intra- and intergenerational equity

This criterion involves attempting to reduce gaps between the rich and the poor and enhance the

Ability of future generations to pursue sustainable lives.

How successful do you think the process is at building equity?

Process evaluation

Sequence of actions

This involves a chain of activities in the learning and teaching process.

How successful do you think the process is at sequencing actions?

PROCESS EVALUATION

Sound Methodology

This involves a structured approach, including monitoring and evaluation.

How successful do you think the process is in terms of soundness of methodology?

PROCESS EVALUATION

Collaboration

This is concerned with collaborative opportunities for students and staff.

How successful do you think the process is creating collaborative processes?

PROCESS EVALUATION

Reflexivity and learning

This involves continuous analysis of actions as well as iterative learning.

How successful do you think the process is at fostering reflexivity and learning?

INPUTS

Awareness

This involves real change in students' consciousness of sustainability issues.

How successful do you think the process is at building sustainability awareness in students?

Inputs

Expertise

This ensures the expertise of widely recognized professionals.

How successful do you think the process is at utilising sustainability experts?

Inputs

Support

This concerns the structural, financial and non-financial resources from UCT.

Does the process secure sufficient support?

Any further comments?

Thank you for your participation

Appendix C: Review of Green IS literature

Authors	Findings	Future Research
Bengtsson and Ågerfalk (2011)	Using the lens of Actor Network Theory , the researchers focused on a range of actor networks, internal and external to a municipality. The researchers found that a thorough understanding of organisational elements was needed to enrol stakeholders. They found that IS can play a central role as tools for improving sustainability indicators.	As the study was qualitative in nature, future research could be quantitative in order to test propositions further. Other frameworks were also suggested. "Future research may complement these insights by applying other theoretical lenses" (Bengtsson & Ågerfalk, 2011, p. 108).
Benitez-Amado and Walczuch (2012)	Drawing on the perspective of IT-enabled organisational capabilities and the literature on organisations and the natural environment, this study introduces the construct of organisational capability for a proactive environmental strategy to the IS field. They used structural equation modelling and collected data from 63 companies. They found IT capability was an enabler of proactive environmental strategy. This research was published in the <i>European Journal of IS</i> .	IS scholars were encouraged to develop survey-based measures and to validate them in confirmatory research projects to extend this study. Also, since this study was conducted at the firm level, it would be useful to test the model at business unit level. Future research could extend the work by studying the moderating effects of business resources.
Berthon and Donnellan (2011)	In this editorial in the <i>Journal of Strategic IS</i> , the authors identify four key domains of Green IS decision-making, which they describe as regulations, technologies, assessment, and consequences. They do not identify which theoretical framework provides the basis for this concept.	The authors describe the new era as the "Technopocene" and caution about unintended consequences. "We need to be watchful of the systems we create and how they change us and the planet. The technopocene requires a new level of mindfulness" (Berthon & Donnellan, 2011, p. 5)
Bose and Luo (2011)	Although the title of this paper suggests that it falls within the domain of Green IT, it draws heavily on IS, rather than IT lenses. The framework is derived from three IS theories: technology-organisation-environment , process-virtualisation and diffusion of innovation . This paper appeared in the <i>Journal of Strategic IS</i> .	The authors provide a research-ready instrument whose properties are validated. They hope their study provides a theoretical framework which sets the stage for future research to examine or extend "the roles of process virtualisation and other critical factors" (Bose & Luo, 2011, p. 52)

Butler (2011)	Published in the <i>Journal of Strategic IS</i> , Butler argues that a new breed of IS — Green IS — has emerged. He draws on institutional theory to explain how regulative, normative and cultural-cognitive factors in an organisation can lead to the design of environmentally-sustainable products. He also builds on organisational theory to describe how the use of Green IS can enable sense-making, decision making and knowledge creation around environmental sustainability.	Butler makes a number of theoretical propositions ready for testing. For example: “If the Green IS facilitates: (1) Network cultivation such that ... teams can be established to enable shared decision making and knowledge sharing; (2) the diffusion of governance, risk and compliance practices; (3) the translation of the concepts for application with the organisation; (4) bricolage, so that (a) processes and products can be modified to manage compliance and reduce risk ... regarding environmental sustainability” (Butler, 2011, p. 23).
Cooper and Molla (2016)	The authors develop a model which shows how sustainable IS triggers knowledge exposure, and prior experience influences IS-environmental absorptive capacity . They also show the links between environmentally-sustainable IS assimilation with cost saving, operational performance, and reputation of organisations. This paper appeared in the <i>IS Journal</i> .	This paper does not test the environmental outcomes, so this is an avenue for future work. Future studies might investigate the environmental outcomes of developing IS-environmental absorptive capacity, including the efficiency of generating, distributing and using energy; reduction in energy utilisation and carbon dioxide, behavioural changes and reduction of e-waste (Cooper & Molla, 2017).
Corbett (2013)	Based on the theory of persuasive systems design , this paper explores how a category of Green IS, carbon management systems (CMS) can be designed and to change behaviours. “The results from three organizational case studies suggest that CMS can be effective at changing employees’ environmental behaviors, demonstrate the extent to which persuasive system design principles (including an emergent category of Integration) are reflected in CMS, and highlight the importance of understanding the persuasion context” (Corbett, 2013, p. 339).	Four areas of future research are identified in the paper: definition and operationalisation of the dependent variable, theory testing and refinement, application of concepts to other applications of Green IS, and further investigation of crossover and boundary-spanning CMS. The issue of environmental sustainability is one of the most difficult and complex challenges that humans have faced, and there are few simple solutions to the problem” (Corbett, 2013, p. 365).

Dao, Langella and Carbo (2011)	Using the resource-based view as a theoretical lens, this paper develops an integrated sustainability framework, combining human, supply chain, and IT resources to enable firms to develop sustainability capabilities and sustainable values to stakeholders and thus gain competitive advantage. Roles of automate, informate, transform, and infrastructure are examined in the development of sustainability capabilities. This article was in the special issue of the <i>Journal of Strategic IS</i> .	Their research demonstrated the need to go beyond initiatives aimed at reducing IT's energy consumption. They also recommended greater alignment. They argue: "future research on IT and sustainability needs to take a more integrated approach ... examine how other resources – such as accounting, finance, and marketing – can be integrated with IT resources" (Dao et al., 2011, p. 76).
Elliot (2011)	Writing in <i>MISQ</i> , Elliot uses Systems Thinking to develop a holistic, transdisciplinary, integrative framework for IT-enabled business transformation for sustainability. He focuses on business as this was a key contributor for responding to environmental challenges through its capacity for innovation and change. His paper provides a resource, not only for IS scholars but also other disciplines to do multidisciplinary research. His findings are based on analysis of examples from 12 different academic disciplines.	Elliot asks a number of questions which remain relevant for future scholars. For example: "(1) What is meant by environmental sustainability ? (2) What are its major challenges? (3) What is being done about these challenges? (4) What needs to be done?" (Elliot, 2011, p. 197).
Gholami, Watson, Molla, et al. (2016)	The authors find that the emergence of Green IS as an academic discipline is "too slow relative to the needs of society. Too few people are working on green IS given its importance, and fewer still are publishing papers about IS solutions that could contribute to dealing with climate change ... We speculate on some reasons for why and explore how the IS discipline can grasp the opportunity to contribute to one of the most important societal challenges... We discuss each barrier and propose solutions" (Gholami, Watson, Molla, et al., 2016, p. 521).	"Global climate change is a pressing problem, and we need to apply current IS theories now to address this significant threat. Our journals are full of theories, but they create little value if they are only of interest to other IS researchers. We need to apply the theories we have. We need also to recognise that solutions often require multiple" (Gholami, Watson, Molla, et al., 2016, p. 529).

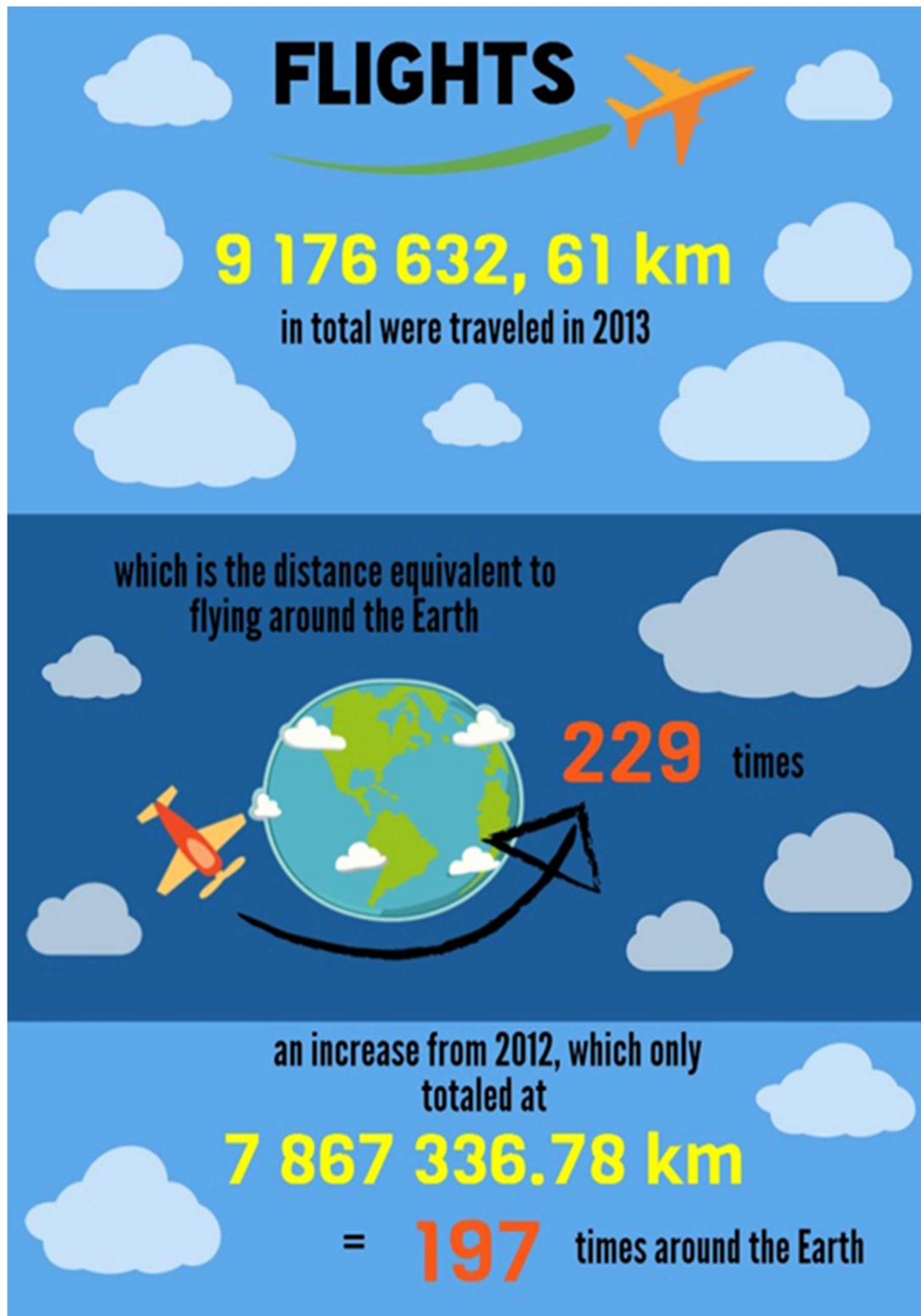
Hasan, Smith and Finnegan (2016)	The paper focuses on climate change adaptation and shows how IS researchers and stakeholders can engage in the challenge. They draw on activity theory and use action research with collaborative engagement and scholarly reflections. The findings show that activity theory can provide the balance needed between strategy and detail for climate change adaptation.	They recommend that future research should identify, understand and resolve tensions between stakeholders; explore different perspectives; acknowledge the mediating power of IS tools and address the emerging relationship between IS tools and adaptation activities.
Henfridsson and Lind (2014)	The paper contributes a new process model to the IS strategy literature by incorporating the commitment to be “green, safe, and connected”. The model has its foundation in Jarzabkowski’s strategy-as-practice lens as well as Mintzberg’s strategy typology. The publication appeared in the <i>Journal of Strategic IS</i> .	Future studies could address several limitations in their work, such as extending the research to other settings. Comparative studies could be useful to detect differences (Henfridsson & Lind, 2014).
Hedman and Henningsson (2016)	This paper demonstrates via a case study the process in which people become Green IS champions in organisations. They found that endorsement for Green IS happens if it fits with the agenda of the organisation and relates to the firm’s strategy. They drew on sensemaking and other organisational theories as lenses for the study. The research was published in the <i>IS Journal</i> .	Future research could examine other organisations that put equal value on sustainability and economic profitability to reach a deeper understanding of the role of Green IS in such processes.

(Loock et al., 2013)	<p>This research explored the role of IS in encouraging energy-efficient behaviour in households, using a web portal system. They chose the extended model of goal-directed behaviour as their theoretical framework. Using data from 1 791 consumers, they found a positive impact of goal setting on energy conservation, with appropriate default goals leading to significant savings. However, if the default goals were too low or too high, this had a negative effect on behaviour. The results extend knowledge of goal setting with implications for the design of effective energy feedback systems. This study was published in <i>MISQ</i>.</p>	<p>The authors argue that the hypotheses rooted in the “behavioral sciences and design-oriented IS research—can serve as a powerful tool to fundamentally extend our understanding of both user behaviour within the IS context and consumer choice in general settings. This especially holds true for IS that grant direct access to fine-grained behavioural data, for example, as smart metering does for electricity, gas, or water consumption. Such systems make it possible to measure the effects of behavioural interventions over time for a large number of consumers, in real-world-settings, and with very little interference between measurement activity and measured object. Second, opportunities for future research arises from a large number of interventions that deserve a better understanding as they might help to increase the overall effect of feedback systems on energy efficiency. Examples of interventions worth investigating are social normative feedback, competitions, framing, social incentives, and rewards” (Loock et al., 2013, p. 1328).</p>
(Malhotra et al., 2013)	<p>This MISQ paper intended to spur impactful research Green IS. They argue: “The challenge of climate change poses enormous and widespread risk to people, societies, and the natural environment. The threat is real. The threat is colossal. And the threat is ever increasing” (Malhotra et al., 2013). They review both Green IS and Green IT.</p>	<p>“Traditionally, IS research has focused on the early stages of the value space of research (conceptualize and analyze), and we have left it to practitioners to translate our work into social advances (design and impact). This tradition ... has not served our field well” (Malhotra et al., 2013, p. 1270).</p>

Marett, Otondo, and Taylor (2013)	<p>This paper in <i>MISQ</i> analyses the factors for successful and sustained use of Green IS in the trucking industry. The lenses included intrinsic motivation theory.</p> <p>They found that while economic benefits encouraged drivers to use bypass systems, the environmental benefits did not.</p>	<p>Reviewers observe: “there are two critical aspects of future IS research. First, to learn how to create accurate systems for pricing environmental damage ... and investigate how the presentation of information can influence perceptions” (Malhotra et al., 2013 p. 1269).</p>
Melville (2010)	<p>Melville shows in this seminal <i>MISQ</i> article how IS can play a key role in shaping the beliefs of stakeholders about the environment, and also enable and transform processes in organisations to achieve environmental and economic goals. Based on Coleman’s Micro-Macro model (1994), he develops the (BAO) framework and a research agenda to provide the basis for “a new discourse on IS for sustainability”.</p>	<p>Melville identifies a range of Research Questions including the following for future studies:</p> <p>“RQ1: How can different philosophical perspectives — positivist, interpretive, critical, and design—be applied to complex problems involving IS, organisations, and the natural environment?</p> <p>RQ2: How can different theories be applied to complex problems involving IS, organizations, and the natural environment?</p> <p>RQ3: How can different research methodologies be applied to examine complex problems involving IS, organizations, and the natural environment?</p> <p>RQ4: How can different environmental metrics, such as CO₂ equivalent, be employed to assess the impact of IS on the natural environment?</p> <p>RQ5a: What is the impact of IS on beliefs about the natural environment and environmental sustainability?</p> <p>RQ5b: What design approaches are effective for developing IS that influence human beliefs about the natural environment?</p> <p>RQ6: How do the distinctive characteristics of the environmental sustainability context affect usage of IS for environmental sustainability?” (Melville, 2010, p. 9).</p>

Petrini and Pozzebon (2009)	This paper explores how the management of sustainability can be supported by Business Intelligence (BI) systems. They argue that BI can play a role in aiding organisations to implement and monitor sustainable practices, especially in the information planning phase, via defining relevant information. Drawing on grounded theory they propose a model to support the integration of indicators into strategy. The Indicators in Perspective model categorise social, environmental and economic indicators in a way that allows evaluation and analysis of strategy in a single frame of reference. This paper was published in the <i>Journal of Strategic IS</i> .	The authors recommend that future researchers could refine and extend the model, by transferring it to different contexts and in real-world situations, possibly with action research (Petrini & Pozzebon, 2009).
Pitt et al (2011)	Writing in the <i>Journal of Strategic IS</i> , the authors argue that smartphones “are both green technologies and an integral part of green IS that are beginning to make serious contributions toward a sustainable environment” (Pitt et al., 2011, p. 27). They draw on U-Commerce as a lens.	Future opportunities for researchers could include revalidating existing theories and developing new theories regarding the use of smartphones, and their potential Green IS impact.
Seidel, Recker and Vom Brocke (2013)	This paper in <i>MISQ</i> develops “a theoretical framework based on the affordances view to suggest characteristics of Green IS that enables organisational transformation. They highlight the key affordances of Green IS that present an organisation with a set of options for transformation.” (Malhotra et al., 2013, p. 1266). They draw on lenses related to socio-technical systems theory, functional affordances, and sensemaking (Seidel et al., 2013).	Reviewers note that this research “stimulates us to pose two critical questions. First, how do we identify the case or cases that reveal eco-effective affordances and their corresponding transformational power? Second, beyond observing best practice, how do we to apply theory and design science to rise above the incrementalism of eco-efficiency to create radical changes?” (Malhotra et al., 2013, p. 1268).

<p>Watson, Boudreau, Chen, and Sepúlveda (2011)</p>	<p>Writing in the <i>Journal of Strategic IS</i> they utilise the theory of the four information drives (ubiquity, uniqueness, unison, and universality) and apply them in a physical setting. They argue that a customer orientation for developing system requirements will be insufficient to create the breakthroughs necessary to reduce harmful carbon emissions. Rather, an innovation orientation is required to develop an effective Green IS.</p>	<p>The authors call for action research. “We need to get involved in addressing how ... to advance sustainable behaviour and eco-effectiveness. IS scholars need to find opportunities to work with teams designing and implementing systems to advance sustainability and investigate dynamically and iteratively how to use information to change behaviour” (Watson, Boudreau, Chen, & Sepúlveda, 2011, p. 60).</p>
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So how much do we waste exactly?

If we weighed the amount of solid waste produced by UCT in 2013...



It would weigh more than 27 humpback whales

1123,23 tonnes



And if all of the pages printed in 2013 were stacked on top of each other...

It would tower above 3 Table mountains

41 621 695 pages

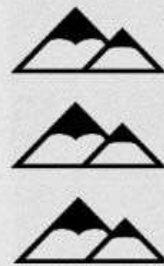
3 Table mountains



4162m



3255m



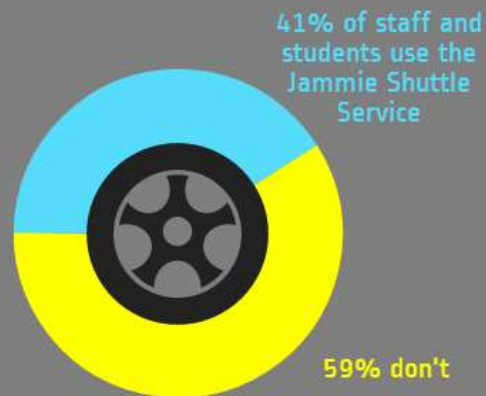
JAMMIE SHUTTLE

Total fuel used in 2013

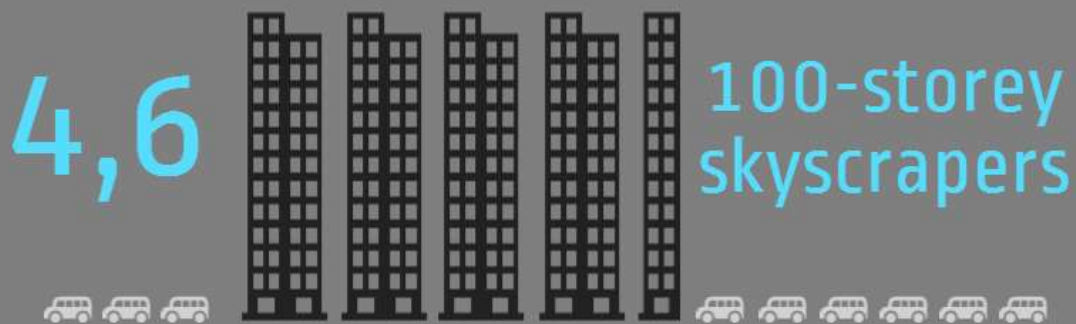
»»»» 400 000 L

Which emits

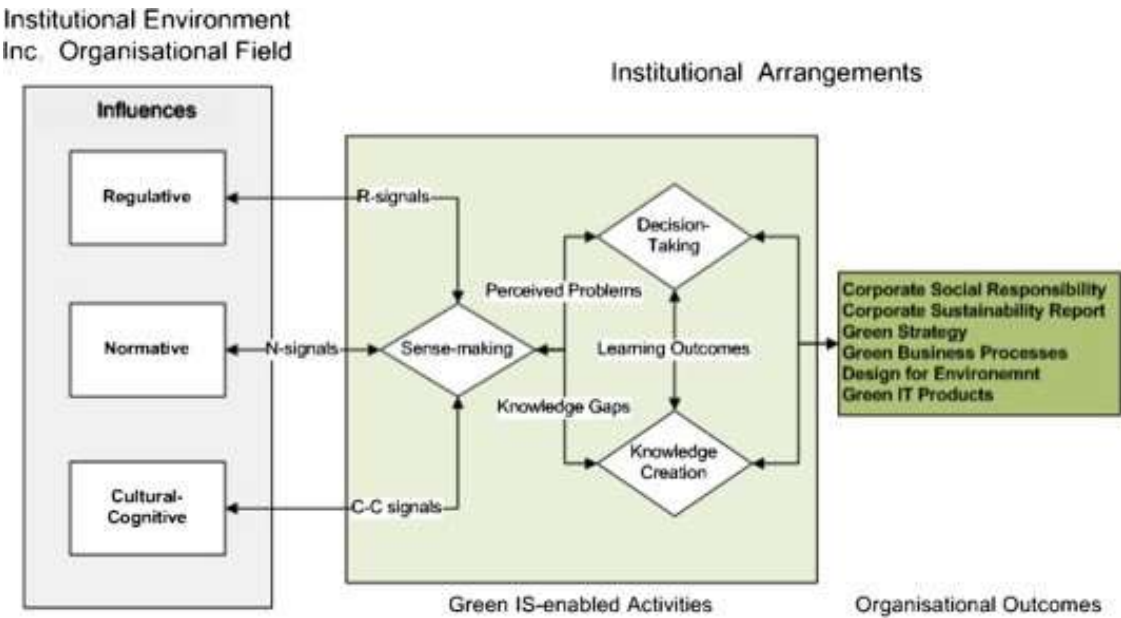
»»»» 1 040 320
tons of CO₂



»»»» a mass equivalent to



Appendix E: Butler's Green IS theory (2011)



Appendix F: Butler’s Green IS theory (2012)

